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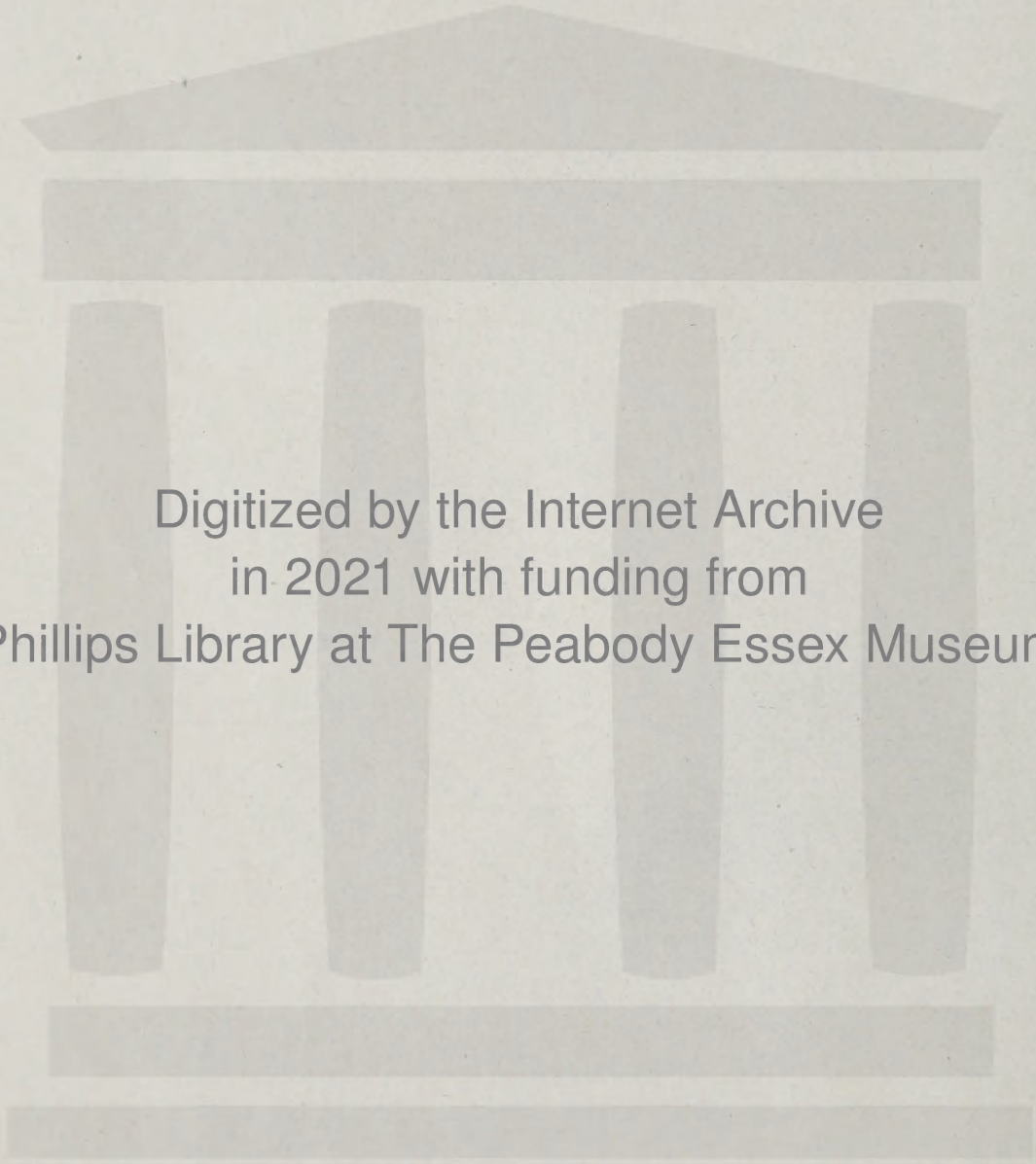
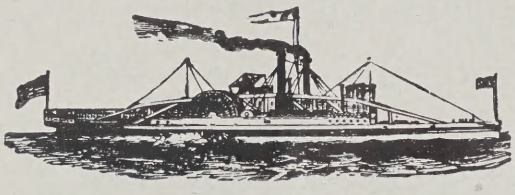


IRON AND STEEL HULL STEAM VESSELS OF THE UNITED STATES

1825-1905

by

JOHN HARRISON MORRISON



Indexed and with a Foreword by
Alexander Crosby Brown

THE STEAMSHIP HISTORICAL SOCIETY OF AMERICA
Peabody Museum, Salem, Massachusetts
1945

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PUBLICATIONS OF THE STEAMSHIP HISTORICAL SOCIETY OF AMERICA

Reprint Series No. 1 — 35¢
"The Sylvan Steamboats On The East River - New York to Harlem," by Alexander J. Wall (New York Historical Society Quarterly Bulletin. VIII, 1924-1925).

Reprint Series No. 2 — 50¢
"History of Steam Navigation between New York and Providence from 1792 to 1877," by Charles H. Dow (New York: Turner & Co., Printers, 1877).

Reprint Series No. 3 — 50¢
"Iron and Steel Hull Steam Vessels of the United States, 1825-1905," by John H. Morrison (Scientific American Supplement, 1905).

"Steamboat Bill of Facts," — $1.00 per annum
Journal of The Steamship Historical Society of America (Sixth Year of Publication).

Correspondence concerning The Steamship Historical Society of America, membership in the Society, orders for the Reprint Series, or current subscriptions to "Steamboat Bill of Facts" may be addressed to the Society, in care of the Peabody Museum, Salem, Massachusetts.

* * *

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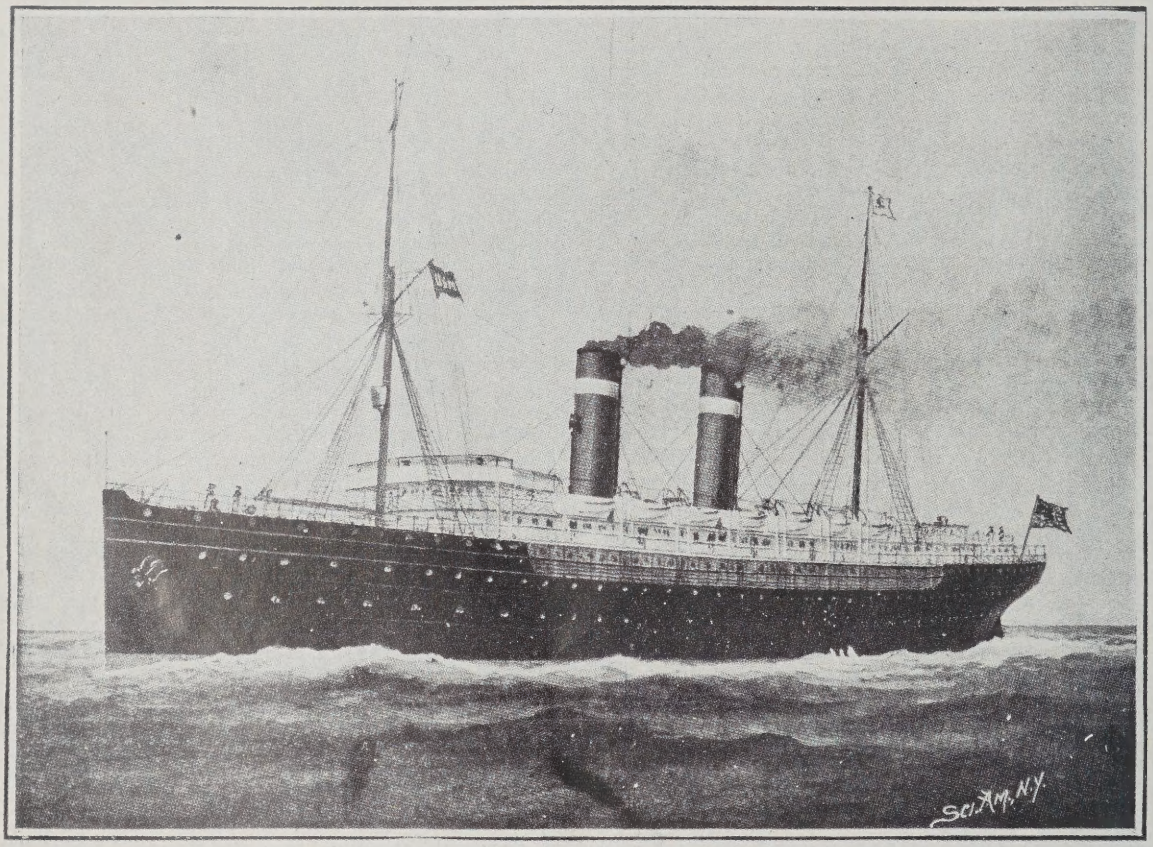


ATLANTIC OCEAN STEEL STEAMSHIP "ST. LOUIS."

FOREWORD

At the 1941 annual meeting of the Steamship Historical Society of America, it was decided to publish a series of reprints of scarce or inaccessible articles or booklets relating to steamship history. The first title produced by the Society was The Sylvan Steamboats on the East River by Alexander J. Wall. This was followed by Charles H. Dow's History of Steam Navigation between New York & Providence.

John H. Morrison is the author of this, the third of the Society's Reprint Series. Morrison has long been an acknowledged authority on American steamships and his History of American Steam Navigation, published in 1903, is invariably consulted for source material on this phase of American enterprise. Today few persons know of an excellent article he wrote two years later, entitled "Iron and Steel Hull Steam Vessels of the United States." This article, expressly written for the Scientific American Supplement, appeared in six serialized installments in numbers 1555 through 1560 (21 October - 25 November 1905).

The fact that Morrison's books are frequently referred to in print, and his Scientific American Supplement article only once to my knowledge, and that in a work of my own, supports the supposition that to all intents and purposes "Iron and Steel Hull Steam Vessels" is presently unknown. And it would be likely to remain so, due to the bulk and inaccessibility of the estimable but prolific perodical in which it is buried.

The present publication, which should render this work more generally useful, has been made possible through the kind permission of the editor of the Scientific American from photostats of the article furnished by the Office of Naval Records and Library, Navy Department, Washington, D.C. Morrison's text has been clipped and remounted in double-column form, all material from unrelated flanking articles in the three-column original being omitted. The text is, however, an exact facsimile and contains the minor errors, such as spelling KOREA incorrectly, inherent in the original.

John H. Morrison, long a resident of Brooklyn, was born in 1841 and died at his summer home at Ocean Grove, N.J., in 1917. A brief obituary notice in the New York Times of 29 August 1917 described him as a "retired constructor of steam engines and ships and widely known as an author on marine topics." In early life he was secretary to Charles W. Kirkland, then inspector of United States Lighthouses. Later he was president of the Morrison Manufacturing Company of Norwood, N.J., and member of the Navy League and other maritime organizations. The following bibliography does not purport to be complete, but it may be of use in indicating the scope of his writings.

BOOKS

History of American Steam Navigation, New York: W. F. Sametz, 1903.
History of New York Shipyards, New York: W. F. Sametz, 1909.
Are there Equinoctial Storms? Development of the Marine Barometer in American Waters, New York: W. F. Sametz, 1911.

ARTICLES

"Life-saving Equipment for Steam Vessels and Government Inspection," Scientific American, 9 July 1904.
"Fire Protection for Steam Vessels and Government Regulations," Scientific American Supplement, 16 July 1904.
"Iron and Steel Hull Steam Vessels of the United States," Scientific American Supplement, 21 October - 25 November 1905.
"St. Swithin's Day - Origin of the Legend," Scientific American Supplement, 10 August 1907.
"The Development of Armored War Vessels - Armor Plating in the United States," Scientific American Supplement, 31 August - 30 November 1907.
"Robert Fulton and the Sidewheel Steamboat," Scientific American Supplement, 2 November 1907.
"The Development of American Oil Tankers," International Marine Engineering, March - April 1917.

Alexandria, Virginia
July 1945

ALEXANDER CROSBY BROWN
Lieutenant, USNR

IRON AND STEEL HULL STEAM VESSELS OF THE UNITED STATES.*

By J. H. Morrison, Author of "History of American Steam Navigation."

I. EXPERIMENTAL PERIOD.

The record of the early manufacture of plate iron in this country is very incomplete, to take the most favorable view of it. The producer had no desire to make public any improvement he had made in the manufacture of iron for fear a competitor would appropriate his improvements, to his disadvantage. Besides, there were no publications in this country at the time that catered especially to the iron-manufacturing industry. Such data as can be found on the subject show that prior to about 1800 plate iron was made, or finished, under the tilting hammer; and it is doubtful if there was anything but light sheet iron made between iron rollers, and it must all have been of a very rough surface finish. Such wrought-iron plate as was used for building steam boilers was of English manufacture, as it is found by the advertisements in the daily papers of that period of the arrivals at different times of "— tons English plate iron," "— tons Swedish bar iron," or "— tons Russia sheet iron," that was offered for sale by some commission merchant in the large cities. We also find that Oliver Evans began the construction of the high-pressure cylindrical boiler at Philadelphia, Pa., about 1802, that was built in all probability of iron, as sheet copper would have been very expensive to use in its construction. There were several manufacturers located along the Atlantic coast at this time, and at Pittsburg, Pa., that operated their machinery by steam power. These steam engines were largely of Oliver Evans's manufacture. There were three or four marine boilers built of plate iron by Robert McQueen, of New York, in 1811 and 1813, for steamboats on the Hudson River and the Potomac River, but whether of domestic or foreign material is not positively known. It would not be surprising to find that the iron for these boilers had been especially rolled for the contractors in this country. A copper boiler for a steamboat at this time was a costly piece of work, and iron was sought on account of the less first cost. The iron-rolling mills were also becoming better fitted to produce at this time rolled iron heavier than common sheet iron. The making of rolled boiler plate would seem to have begun as a regular merchantable article in this country about 1815 or 1820, but whether on the Atlantic coast or at Pittsburg, Pa., where the high-pressure marine engine and the plain cylindrical marine boiler first took form about 1817, seems to be a doubt. In 1823 there were but four steamboats in New York waters having iron boilers, the boilers of the other steam vessels being of copper. It is claimed that the Brandywine rolling mill of Charles Lukens at Coatesville, Pa., made the first wrought-iron boiler plate in this country between 1816 and 1825. Imported wrought-iron boiler plate was used for the construction of boilers many years before its manufacture in this country.

About the earliest writing on the making of sheet iron in this country is that by Prof. Thomas Cooper, of Dickinson College of Pennsylvania, in 1813, where he says: "In consequence of information requested of me, I have found it necessary to make some inquiries as to the manufacture of sheet iron. The fault of this article when made in this country is stated to be that the plates or sheets are rough and uneven, in consequence of the scales they acquire in the process of heating for the purpose of being rolled. The appearance of the plates is mended by being annealed or slightly blued, but this is no cure for the evil. My notions on the subject are these:

"Every metal, particularly iron, when exposed to atmospheric air in a red heat, will attract and combine with the oxygen of the atmosphere, and become oxidized. The oxidized iron will either scale off, or remain upon the plate in the form of scales, and make it rough. The cause of the scales and of the roughness of the surface, therefore, is oxidized iron. The cause of the iron becoming oxidized is that a current of air not deprived of its oxygen by the coals comes in contact with the hot iron, and deposits its unconsumed oxygen in the metal.

"When a plate of iron is laid upon charcoal for the purpose of being heated previous to its being rolled, the interstices of the charcoal admit more air than the charcoal can consume, or de-oxygenate; that air combines with the underside of the plate, which thereby becomes rough and scaly; the upper side of the plate becomes less so, because the air that passes over it is in part deprived of its oxygen. If there be three plates, the bottom of the undermost will be most oxidized, and then the top of the uppermost; the middle plate will be free from scales. It is heated in the same manner as if it were in a muffle, which is the method of heating the iron intended to be rolled, in some parts of England, and effectually prevents the imperfection complained of.

"If instead of charcoal a bituminous stone coal is used, the iron plate comes away from the fire much purer and cleaner. The coals are apt to coke together, and admit no more air through them than they can decompose; besides which, the smoke of the coal greatly tends to decompose the current of air which passes immediately under the lowest plate. Coal, therefore, is the best fuel for the purpose, that is, the coal that smokes and flames while it burns.

"But, *if the rollers be well greased* while the iron is passing through them, which they ought to be, the scales separate, the surface becomes smooth, and a fine bluish color can be afterward given by proper annealing, if it be necessary to please the eyesight."

The period from 1835 to 1840, when it may be said iron shipbuilding was introduced in the United States, was one of many changes in marine engineering and shipbuilding in this country, the result of many experiments and trials. Those that have stood the test of time have been: the adoption of the iron boiler in place of those made of sheet copper; the introduction of the independent engine to operate a fan blower, for increasing the draft of the furnaces of the boiler; and the adoption of the screw propeller. Another period, but more recent, was from 1870 to 1875 in the general laying aside of wooden-hull steam vessels on the Atlantic coast, except those for special service, and the larger development of the iron shipbuilding industry, with the introduction at the same time of the compound engine for screw steamers.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

The use of iron in the construction of the hulls of steam vessels for the merchant service was not given a great deal of attention in this country until about 1850, for our supply of timber for shipbuilding seemed at the time to be inexhaustible. It is true there were several passenger, freight, and canal boats built of iron prior to that date, but they were small in number and in tonnage to the wooden hulls built during the same period, and with a few exceptions were for inland service. Among those that were first in operation in this country, were those that were constructed in England for the Savannah River, Georgia. There were also built several steamers for the United States revenue marine service and two for the United States navy during this period.

The larger number of iron steam vessels built for the Atlantic coast up to about 1844 were constructed at the large marine engine works at New York city, but after that year iron shipbuilding yards were established at Wilmington, Del., Philadelphia, Pa., and Camden, N. J., on the Delaware River, since which time but few iron hulls have been built at New York city and the immediate vicinity. There were a number built at a later period for the domestic and also foreign service at Boston, Mass., but few have been built there of late years.

The pioneer of the iron-hull steam vessels in the United States appears to have been one built at York, Pa., in 1825 on the Susquehanna River, and named "Codorus." It was a very small affair, entirely of iron, and was undoubtedly an experiment. The dimensions of the vessel were 60 x 9 x 3 feet deep, with a draft of 12 inches. The ribs were "bent to a greater strength than flat iron," and placed 12 inches apart, probably shaped similar to an angle iron. There is no record left whether this vessel was fitted with side wheels or a stern wheel. They used wood as a fuel in the boiler. The boat remained on the Susquehanna River about two years without any permanent employment, was then taken to Baltimore, Md., and the last record left of the vessel appears that in January, 1829, she was sent to North Carolina to run between Newberne and Beaufort. A Baltimore paper in April, 1830, published under the heading of "The First Iron Steamboat": "We have two or three times during the past year endeavored to set history right in regard to the place at which the first iron steamboat was built in America. The steamboat 'Codorus' was the first iron steamboat built in the United States, as has been repeatedly stated in this and other papers. . . . It was built at York, the hull altogether of iron. . . . The 'Codorus' was afterward brought to this city, where after remaining some time was taken farther south to ply on some small river." The iron was of domestic manufacture.

There does not appear to have been anything further done with iron hulls in the United States until 1835, when a double or twin hull boat was constructed by L. Parmalee, of Poughkeepsie, N. Y., of 5/32-inch plate iron "riveted together in a manner similar to the iron in steam boilers." Each hull was 63 feet by 29 feet 9 inches by 1 foot 8 inches deep, connected together by beams, and these secured to an ash strip riveted to the upper side of each hull, leaving a space of six feet between the inside of the hulls. On these beams the deck was laid, which supported the machinery, the latter being a small horizontal engine and a locomotive boiler, driving a paddle wheel between the hulls. Draft of water, 9 inches. On the trial in October, 1835, on the Erie Canal, where it was designed to place the vessel in use, the engine was found to be too small to obtain a speed over seven miles an hour. As there is no record found of any further trials with the vessel, it may probably be accounted for by the fact of the canal commissioners not approving of the use of steam vessels in the canal for fear of the washing of the banks, through the operation of the wheels and the intended velocity of the vessel. The limit of speed at this day, as fixed by the commissioners, was four miles per hour. This boat was built but a year after Henry Burden, of Troy, N. Y., had constructed the double-hull steamboat "Helen" of wood, for use on the Hudson River.

There was also built in 1836, in the western part of the State of New York, three or four iron-hull canal boats, or barges, as an opposition line of packet boats on the Erie Canal between Rochester and Buffalo, N. Y. In the next year several iron canal boats were built for transportation companies, for freighting on the Pennsylvania State canals, across the Alleghany Mountains to Pittsburg, connecting the Delaware and the Ohio rivers. Some of these vessels were made in several distinct sections, so that when they arrived at a junction of the railroad and canal, they could be readily hoisted with their merchandise to a freight car, transported across the mountains, and again placed in the canal.

The first iron-hull steam vessel built in this country, that was more than an experiment, was the "United States," constructed at the West Point Foundry in New York, from design of Charles W. Copeland, their superintending engineer, for service on Lake Pontchartrain and canal, in connection with the railroad to New Orleans, La. This is the same vessel that has been called the "Siamese;" that was the shop name. All the records show her name to have been "United States." The vessel was constructed in the summer and fall of 1838 at the foot of Beach Street, and after the parts had been fitted together, they were taken apart and shipped to New Orleans in sections, and mechanics sent to the latter city by the contractors, who re-erected the vessel, and fitted the machinery on board complete for service. The vessel was built with two hulls, each 110 feet long, 7 feet wide, and 3 feet 6 inches deep, placed so there was a space of 11 feet between the inside of the hulls, or 26 feet extreme breadth of the deck. There were two watertight bulkheads in the ends of each hull. The water wheel between the two hulls was of 13 feet diameter and 8 feet wide, with 14-inch buckets. There was a pair of high-pressure engines, 9½-inch cylinder by 42 inches stroke of piston each, driving the paddle wheel placed in the space between the two hulls; steam being furnished by two return-flue boilers, each 20 feet long and 38 inches diameter, with two 14-inch flues. The draft of water when loaded with passengers and baggage was 22 inches, and her average speed was 10 miles per hour. The total cost of this vessel was $17,500. The T iron used for the frames of the vessel was 3¾ x 1¼ x ½ inches, and the angle iron for reverse bars, etc., 2¾ x 2¾ x ⅜ inches. Plate iron for the bottoms of the hulls was No. 5, for bends No. 6, for top No. 8. The T iron used in the construction of this vessel was rolled expressly for the purpose by the Ulster Iron Company, of New York. A special furnace was erected for heating the plates the whole length, 10 feet, similar to the furnaces used for the same purpose at this day. This vessel after a service of three or four years on Lake Pontchartrain is reported to have been sold to a party at Lavaca, Texas. The last record of her appears in her inspection in 1860 at Savannah, Ga., as "United States," iron, 1841, 222 tons.

The Ulster Iron Company, of New York, made ax iron in 1833 or 1834; rolled boiler plate iron in 1836; drew wire rods for screws in 1836. Also made *the first* iron steering rods for steamboats, that were placed on the "Novelty," which ran on the Hudson River.

In December, 1839, the second iron-hull steamboat—calling the "United States" the first—was named "Valley Forge," and was built at Pittsburg, Pa., by the Washington Works of Robinson & Minis, steam-engine builders of that city, for service on the Ohio and Mississippi rivers. This was the first iron hull on the western rivers, and the first iron-hull *side-wheel* steamboat of American construction and material. Her dimensions were 165 x 25 feet x 5 feet 6 inches depth of hold, but she was subsequently lengthened to 180 feet. Keel plates and bottom were ¼ inch thick, and upper sides 3/16 inch thick, and plating run with in-and-out strakes. Frames were of angle iron. The hull was divided by one longitudinal bulkhead along the center line, and three athwartship bulkheads. The material for the hull was furnished by one of the rolling mills at Pittsburg, Pa. The engines were of the usual type of the western river steamboats—high-pressure noncondensing—having two cylinders, each 16 inches diameter by 8 feet stroke. Steam was furnished by four flue boilers, each 24 feet long. This vessel ran successfully on the Ohio River and the Mississippi River until 1842, when she was sunk by fouling a snag in the latter river, was raised and repaired, and continued in service until 1845, when the hull was sold and broken up, and the machinery transferred to the steamboat "Robert Morris." The plates of the hull were of charcoal iron, and when the vessel was laid aside, were found to be worn so thin on the bottom plates—by friction with the shoals of the rivers it was thought—that she became unserviceable after those few years. Later experience with charcoal iron in the construction of the hull of a vessel in this country showed still farther that it was not the best grade of plate iron for the wetted skin of a vessel. One of our large iron shipbuilders said at the opening of the steel era in shipbuilding in this century: "Charcoal iron does not answer very well for ships. It wears away very quickly, and pits, runs in grooves, and corrosion advances very rapidly in it." This would explain why the "Valley Forge" was so short-lived.

There have been many conflicting accounts made regarding the plate iron used in the hulls of the early iron steamboats, whether of domestic or foreign manufacture, and it may be of interest to say that the only imported plate iron in the construction of the hulls, taken as a whole, of the early American steamboats were those of the Savannah River steamboats, and the "W. W. Fry," of Mobile, Ala.

Prior to the construction of the "United States" in 1838, there were a few iron-hull steamboats on the Savannah River in Georgia, that had been constructed in England. The first of these was the "John Randolph," built by John Laird at Birkenhead, England. At this time iron shipbuilding was a comparatively new industry even on the other side of the Atlantic Ocean. The hull of this vessel was sent over in sections, and re-erected by John Cant, a shipbuilder of Savannah, Ga., and completed in July, 1834. The vessel was 110 x 22 feet x 7 feet 6 inches. The engine was of the low-pressure type, built by Fawcett & Co., of Liverpool, and rated as 40 horse-power. The Hon. G. B. Lamar, of Georgia, the owner of the vessel, wrote to the builder of the hull in 1836 regarding the service of the vessel since her completion, as follows:

"The iron steamboat which you constructed and sent out for me in pieces to Savannah, Ga., in 1834, was received and put up and riveted complete within three months' time; and though five men accustomed to such work had been sent at the same time to complete her, I found the expense of them unnecessary, as the pieces had been so well arranged and marked by you, that no difficulty could occur with persons at all conversant with the ordinary construction of boats or vessels; besides which, a larger one since sent to the same place by you for the Steamboat Company of Georgia was put up in even less time, and without any difficulty. In mine, which was called the 'John Randolph,' was placed an English engine of 30-inch cylinder by 5-feet stroke with heavy iron boiler, steam and other pipes, with which, and water and wood for twelve hours (six cords) she drew but 2 feet 9 inches water. She made her first trip in August, 1834, towing flats with cargoes on the Savannah River, the current of which is two and one-half miles per hour, and with the weight of 8,000 bushels of salt—about 200 tons—up, or 1,500 bales of cotton—about 220 tons—down, on the two flats, she made with 18 revolutions of crank per minute 5 miles per hour upward, and over 8 miles per hour down the stream.

"She was kept in constant employment from August 1834, till April, 1835, when her hull was examined inside and out, and found to be uninjured. From July she was again constantly employed till April, 1836, when she was again examined, and found free from rust and injury, though from July to December the river had been very low, and she had been once aground for a week on a sand bar, and daily while running on and over logs, snags, and other innumerable impediments, as well as the sand bars, during that time working the flats off and over the bars, very frequently during which they were often snagged and otherwise made leaky, while the steamboat itself, though made to take the worst difficulties, when known to the pilots, was not injured, and remained as tight as at first.

"The preparation to prevent the iron rusting was only three coats white lead inside, and three of red lead outside previous to launching; and one coat white lead inside between August, 1834, and April, 1835, and two coats of each at that time inside and out respectively, and one coat white lead inside between July, 1835, and April, 1836.

"In addition to the foregoing conclusive evidence in her favor, I may add that the directors of the Steamboat Company of Georgia, who had been eighteen years engaged in the navigation of that river, and had tried various projects for its improvement, so soon as they observed the condition of the 'Randolph' in April, 1835, when she was first examined, immediately resolved to order the one you sent out for that company in the month of February last.

"I will take the leave to add as my opinion, and from the experience of the 'John Randolph,' that iron boats are decidedly superior to wooden; and for lightness, durability, impregnability to snags, or other injury, must entirely supersede all other vessels in course of time, should the difficulties apprehended in regard to the compass be overcome."

Congress passed an act in February, 1834, authorizing G. B. Lamar, of Savannah, Ga., "to import free of duty an iron steamboat with its machinery and appurtenances, for the purpose of making an experiment of the aptitude of iron steamboats for the navigation of shallow waters." This referred especially to the "John Randolph." The owners of this vessel were prominent at this period, both politically and commercially, in all affairs affecting that section of the country.

The "John Randolph" having proved in the course of a year's service well adapted for the work intended, the Steamboat Company of Georgia placed an order with the builder of the former vessel for one of 120 x 20 feet x 7 feet 6 inches, which was re-erected at Savannah by Edward Nock. Her name was "Chatham." The engine was of the low-pressure type of 46 horse-power, and was fitted with gearing and a large fly-wheel, from an old boat formerly on the river.

The Iron Steamboat Company, owners of the "John Randolph," had the hull of another vessel constructed and sent out in sections to this country by John Laird in 1838, and having dimensions of 115 x 24 x 8 feet hold. This vessel was named "Lamar." Instead of importing the machinery with the hull, the engine and boiler for the vessel were constructed by Watchman & Bratt, steam-engine builders of Baltimore, Md., who also put the hull together at Savannah. A duplicate of this vessel was built during the next year by the same builders and named "Savannah," for the Iron Steamboat Company. All these vessels, built by John Laird, had water-tight bulkheads at the fore and after ends of the machinery space. All of these Savannah steamboats had gone out of service by 1852.

There was another imported hull sent to this country in 1839. This was the "W. W. Fry." There have been many errors spread regarding this vessel, but the facts appear to be that John Laird also built this hull, and about the same time he had shipped a few iron hulls to South America. This hull was sent over in sections, arrived at New Orleans, La., in June, 1839, and was shipped from there to Louisville, Ky., where it was re-erected, but by whom does not so far appear. The vessel was 168 x 28 feet x 7 feet 5 inches. Where the machinery was constructed is somewhat in doubt. Davis Embree in 1851 wrote that the vessel was built in Pittsburg, which is an error, but in all probability is where the machinery was constructed. There were four or five machine shops at this date at Louisville, Ky., and one of these had re-erected the hull of the vessel. A Pittsburg steam-engine builder had probably built the engines and boilers, as they had the call for western river engines in that section at that period. She was launched October 9, 1840, and left Louisville the latter part of November, 1840, for New Orleans. The vessel was owned by Alexander and C. M. Pope, of Mobile, Ala., and was intended for the New Orleans and Mobile trade. Her original cost was $19,834. She was snagged while on the Alabama River in 1842, and on March 29, 1855, was again snagged and sunk while in Mobile Bay, subsequently raised and put again in service. Loss about $500. The vessel was finally laid aside by being beached on the flats opposite Mobile about 1860.

A vessel that was a radical departure at this period was the "Robert F. Stockton," built by J. & M. Laird, of Birkenhead, England, in 1839, for Com. R. F. Stockton, United States navy. This vessel not only had an iron hull, but was fitted with a screw propeller, the first of that type of propulsion since the experiments made by John Stevens some thirty years before. What has given the vessel so much prominence has been the fact of her being the first iron-hull vessel to cross the Atlantic Ocean. There had been iron-hull side-wheel vessels built for river and coastwise service in Great Britain, but this was the first test on the stormy North Atlantic Ocean. Doubts had been entertained if an iron hull was as well fitted for the open sea as a wooden structure. But this voyage set all such doubts at rest. The dimensions of the vessel were 70 x 10 x 3 feet draft, not as large as one of our river tugboats, and the motive power was two engines, each having cylinders 16 x 18-inch stroke. She was brought to New York under sail only, and arrived there May 29, 1839. She was taken, soon after her arrival, to the shops of the Camden & Amboy Railroad Company at Bordentown, N. J., and subjected to many experiments and changes, especially in her motive power. One serious defect was found—that with the two propellers in operation on the one shaft she was very erratic in steering properties; but the removal of one wheel improved her very much. Her rudder was also changed, and placed aft of the propeller. The name was changed by an act of Congress in May, 1840, to "New Jersey." The vessel was placed in service towing barges on the Delaware River and canal, and she continued for about thirty years. This was the first screw vessel that was successfully used for purposes that were not experimental.

II. 1840-1860. ATLANTIC COAST.

A PERIOD had now arrived when it seems that the best results of the early experiments in marine engineering made in this country were ready for application to the iron hull, brought about by the experience obtained by the use of a few sidewheel iron steamboats, and the service of the iron-hull screw propeller "Robert F. Stockton." The conditions were, however, favorable in many ways for the change, from the steamboat owners' as well as the builders' point of view. The operation of our sidewheel boats under a steam pressure of 30 pounds and over, and the general application of the cut-off, made it more favorable to use the short stroke and higher piston speed of the propeller engine. There was no period when there were more numerous experiments made, and greater fallacies exploded regarding the application of a propelling agent to a steam vessel, than from 1840 to 1850. It was in the early days of this period that Robert L. Stevens designed the steam battery of iron for the United States navy, that was to be driven by twin screws; and who was the pioneer in the development of the iron war vessel. John Ericsson was also a very prominent marine engineer during this time, being largely engaged in the application of the screw propeller to merchant vessels.

In 1842 there was built by Stackhouse & Tomlinson, of Pittsburg, Pa., under the supervision of Charles W. Copeland, who was at the time naval engineer of the United States navy, associated with Samuel Hart, naval constructor United States navy, the naval steamer "Michigan." This vessel was put together at Pittsburg, taken down, and shipped in sections *via* the Beaver canal to Erie, Pa., on Lake Erie, where it was re-erected and launched for service on Lake Erie in 1843. Her dimensions are 162 feet 6 inches between perpendiculars, 27 feet beam and 12 feet 5 inches depth of hold. She is a side-wheel vessel, and driven by a pair of inclined condensing engines, each having a cylinder of 36 inches diameter and 8 feet stroke. Some of the scantlings of the vessel are as follows: Frames of T iron, 4½ inches by 4 inches; distance center to center, 24 inches; reverse bars, 4 inches by 2½ inches; floors, 6½ inches by 4½ inches; keel plates, ⅝ inch thick; side plating, 5-16 inch thick; stem and stern posts, 6½ by 1½ inches; sheer strake, ⅜ inch thick, and the iron plating carried up to the rail. Deck beams of both the main and berth decks of T iron. Five heavy box keelsons were run the whole length of the vessel. The iron for the whole of this vessel was rolled by H. S. Spang & Son, of Pine Creek, Pa. This vessel is still

on the register of the Navy Department.

The iron mills of Great Britain were rolling much heavier plate iron at this time than the American rolling mills, for in 1839 the largest plates rolled were by the Colebrookdale Iron Company for Fawcett, Preston & Co., of London, England, of two plates, each measuring 10 feet 7 inches long, 5 feet 1 inch wide, and 7-16 inch thick. They were intended for bottom plates of a steam boiler. The steamship "Great Britain," built in 1841, had keel plates ¾ inch thick in middle of keel and 1 inch at ends. All the underbody plates were ⅝ inch to ½ inch, and sheer strake was ⅝ inch, and double riveted throughout. The angle iron frames were 6 inches by 3½ inches by ½ inch at bottom of vessel, and 7-16 inch thick at the top, having centers of 14 inches. There were ten iron keelsons, of which the center ones were 3 feet 3 inches deep.

In 1842 Moses Starr & Sons, of Philadelphia, Pa., built a small sidewheel boat of 80 feet by 12 feet by 4½ feet deep, of iron, having two high-pressure horizontal engines, and named "Appaquernick." She ran for a short time on the Delaware River, when she was sold and sent to South America.

During the same year there was built by Hogg & Delamater, of the Phenix Foundry at New York city, at the foot of Jane Street, for the Delaware and Raritan Canal Company, from designs furnished by John Ericsson, four iron propeller canal steamboats, each 96 feet long, 24 feet beam, and 7 feet depth of hold. They were named "Anthracite," "Vulcan," "Black Diamond," and "Ironsides." They were each fitted with an engine of the grasshopper type of 18 inches by 24 inches stroke of piston, and driven by twin screws of 5 feet 10 inches diameter. These were the first twin-screw steam vessels in this country. The frames were principally of T iron, and very heavy for the size of the vessel. The iron plating was mainly of American manufacture, though there was some English iron used on the bottoms of two of the vessels. These vessels remained in service until 1850, when the bottom plates of all the vessels were found to be so badly corroded in places, both internally and externally, that they were covered with wood planking. The iron hulls were protected from oxidation with red lead and oil.

Hogg & Delamater, who succeeded James Cunningham at the Phenix Foundry, later in 1842 constructed for H. R. Worthington, of Brooklyn, N. Y., an iron-hull steam canalboat that was named "Pioneer." Her dimensions were 73 feet 10 inches long, 14 feet beam, by 5 feet 7 inches deep. She was placed on a line between New York and Canada *via* the Champlain Canal, but was subsequently in use on the Dismal Swamp Canal in Virginia.

In 1843 and 1844 the United States government had constructed for the Revenue Marine Service, eight iron-hull steamers. On February 28, 1843, contracts were signed for the building of the "Tyler," the "Jefferson," and the "Legare." On April 2 of the same year, the "Dallas" and the "McLane"; on April 18, the "Spencer"; and on December 4, 1844, the "Polk" and the "Walker."

The "Tyler" was built at Pittsburg, Pa., by Charles Knapp, and fitted with Hunter's submerged wheel. She was launched as the "George M. Bibb" April 10, 1845, and was subsequently transferred to the Coast Survey January 9, 1847. She was 161 feet long, 22 feet beam, and 11 feet 10 inches depth of hold. Tonnage, 409 tons.

The "Jefferson" was also built at Pittsburg, Pa., by the same builder as constructed the "Tyler." This vessel was 160 feet long, 24 feet beam, having 9 feet 6 inches draft of water. Her engine was of the horizontal high-pressure type, 36 inches diameter of cylinder and 32 inches stroke of piston, and driving an Ericsson propeller. This vessel, after being put together at the works of the builder, was taken apart and shipped to Oswego on Lake Ontario, where it was re-erected, launched, and finished for service. She was subsequently brought to the Atlantic coast with the "Dallas" by the way of the St. Lawrence River and rapids.

At the time it was contemplated to bring these two vessels from the lakes, there had not been any vessel which had passed down the rapids of the St. Lawrence River drawing over 7 feet, and as these vessels were of a draft of over 9 feet, it became necessary to obtain reliable information as to the greatest draft of water for a vessel to pass down the rapids with safety, before any attempt was made to take them through this dangerous and treacherous part of the river. All inquiries on the matter failed to elicit any definite information. Desiring to get the vessels through to the coast, the Revenue Marine officers were thrown on their own resources, and adopted a plan of their own to obtain the desired information. They procured a large scow, and upon each side placed and fastened two scantlings so that they projected below the bottom of the scow, with the idea that in floating down the rapids, if they should strike any obstruction, they would be torn off, and thus indicate that the shoalest part of the rapids was not as deep as the length of the scantlings below the surface of the water. The scow was started on its first trip for a 7½ feet draft, and the scantlings or gages were intact on the scow's arrival at the foot of the rapids. It was sent on several more trips down the rapids, each time increasing the length of the gages till there was found to be sufficient water to float these vessels with safety. The scow was sent down till the gages were torn off in passing down the rapids, and the depth of water was then estimated to be about 12 feet in the shoalest spot in the channel.

The "Legare" was built at New York by H. R. Dunham & Co., marine engine builders. Her dimensions were 160 feet long, 24 feet beam, 11 feet deep, and drew 9 feet of water. This vessel was designed by John Ericsson, engineer, of New York city, and was fitted with a screw propeller. The power was derived from one horizontal high-pressure engine, the cylinder being 36 inches diameter and 32 inches stroke. After a few years' service for the United States government, she was sold to private parties, who placed her in the merchant service, and changed her name to "Commerce."

The "Dallas" was built by Stillman, Allen & Co., the Novelty Iron Works, of New York city. She was of the same dimensions as the "Tyler." The vessel was put up at New York, taken down, and erected again at Buffalo, N. Y., and launched April 4, 1846. She was fitted with the ordinary radial wheel. This vessel was brought to the coast about 1850, and on March 4, 1851, was sold at New York to E. Campbell.

The "McLane" was contracted for by Cyrus Alger, of Boston, Mass., but was built by Jabez Coney at South Boston. She was originally constructed with Hunter's submerged wheel, but was changed to a sidewheel vessel before being put in commission, without alteration of her engines. Her dimensions were 161 feet long, 22 feet beam, and 11 feet 10 inches depth of hold, with a mean draft of water of 9 feet 6 inches. Her engines were two horizontal non-condensing engines, having cylinders each 24 inches diameter with 36 inches stroke of piston. Sidewheels, 16 feet 5 inches diameter and 5 feet 11 inches face. Engines were geared to the shaft in proportion of 65 revolutions of the wheels for each 100 revolutions of the

engines. Her trial trips were made April 15, 16, and 17, 1846. In 1847 the hull was converted into a lightship and stationed off the passes of the Mississippi River by order of the Secretary of the Treasury.

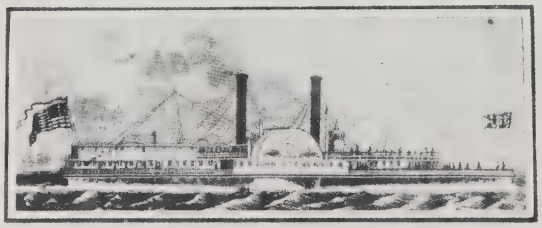
The "Spencer" was constructed by the West Point Foundry Association at Cold Spring, N. Y., and was ready for service in May, 1844. This vessel was of the same dimensions as the "McLane," and was originally fitted with Hunter's submerged wheels, but after several experimental trials, these wheels were removed and two Loper propellers, each 8 feet diameter with four blades, substituted. Her engines were of the same size as the "McLane's," and geared to propeller shaft in proportion of one revolution of the engine to 1.25 revolutions of propellers.

Both the "McLane" and the "Spencer" were very poor models, and in several experiments which were made with these vessels by the Revenue Marine Bureau in May, 1846, on Long Island Sound, from New London to Saybrook, to endeavor to find which was the most effectual and economical the propeller or side wheel—the best speed that was to be obtained from either one under favorable circumstances was about 7 miles an hour. The hull of the "Spencer" was in 1848 converted into a lightship, and stationed off the James River, Virginia.

The "Polk" was contracted for and built by J. R. Anderson, of Tredegar Iron Works, Richmond, Va., December 4, 1844, and was a sidewheel steamboat of 128 feet by 26 feet by 10 feet 6 inches, fitted with two of Lighthall's half beam engines. She performed a few years of sea service, and in 1849 was converted into a bark, and subsequently sold at San Francisco, Cal., in December, 1854.

The "Walker" was built by Joseph Tomlinson, of Pittsburg, Pa., and was similar in size to the "Polk." She sailed from Pittsburg to New Orleans in December, 1847, and was transferred to the Coast Survey. Her draft of water was 6 feet 6 inches.

At this time the United States government were engaged in making many experiments with steam vessels, both for those in the naval service as well as those of other departments of the government, and of all the costly experiments of the period there was



STEAMER "JOHN STEVENS," 1845.

none that proved more valuable in experience than that with Hunter's submerged wheel, such as was placed on the "Alleghany" and other naval vessels. These iron vessels that were the first steam vessels in the Revenue Marine Service, were a great success as failures, in almost every regard in both hull and motive power. They cost about $85,000 each when finished. This was the period of the experimental stage of the screw propeller in this country, and has been noted as the time of the war of the propeller.

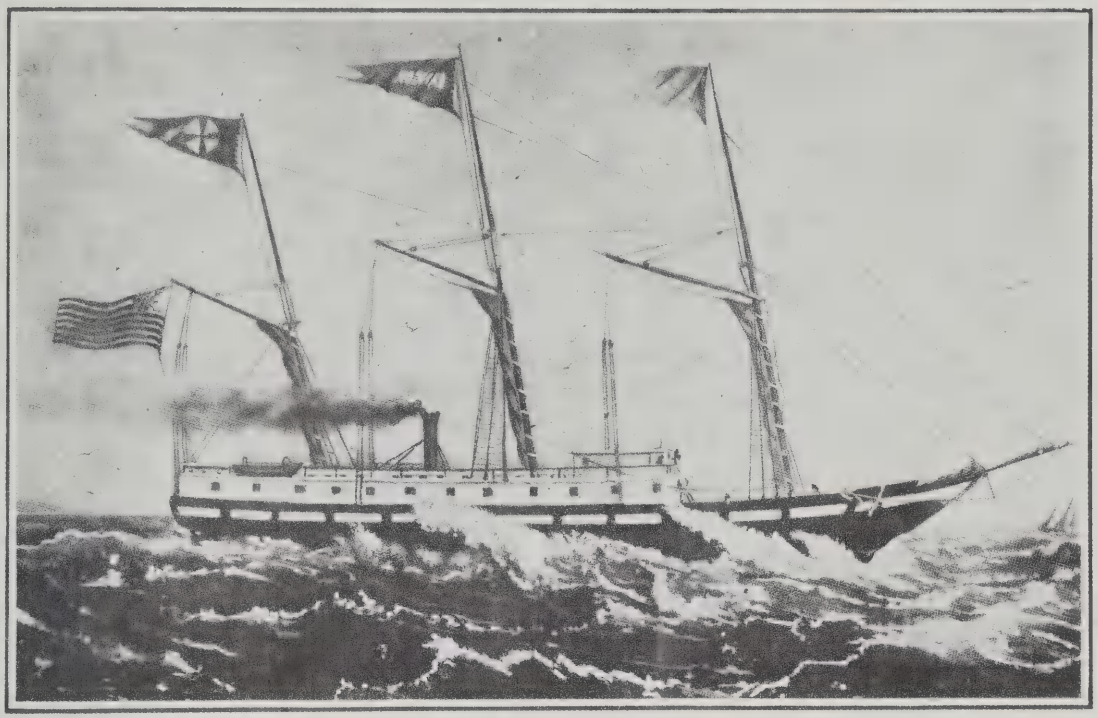
John F. Starr, who had a machine and boiler shop at Camden, N. J., in 1843, built for the Baltimore and Philadelphia Steamboat Company the twin-screw propeller "Conestoga," she being 80 feet long, 16 feet beam, and 6 feet deep. He also built the boiler and propellers for the vessel, the latter being originally of Ericsson's patent. The engine was constructed by Reanie, Neafie & Co., and had a cylinder 16 inches by 16 inches.

The West Point Foundry Association in April, 1844, commenced the construction at Cold Spring, N. Y., of an iron-hull vessel that was named "Margaret Kemble," for Myers & Co., of Norfolk, Va. This vessel was 92 feet by 17 feet by 7 feet. The bottom plates were ¼ inch thick, and sides of 3-16-inch iron. Deck of white pine and deck beams of yellow pine. Two wood bulkheads were fitted in the hold of the vessel. There were two horizontal engines, with cylinders each of 16 inches diameter by 24 inches stroke, and a boiler having 600 square feet fire surface, built for carrying 60 pounds pressure of steam. There was also fitted two Hunter wheels, 8 feet diameter and 2 feet wide, inside paddle 12 inches deep. These engines and wheels were subsequently removed, and a beam engine of 22 inches cylinder by 5 feet stroke, which had been taken out of one of the early New York and Brooklyn ferryboats, and the ordinary paddle wheels substituted in their stead. This vessel was in service in New York harbor as a towboat, and at one time was the property of the Morris Canal and Banking Company.

In the same year Betts, Harlan & Hollingsworth, of Wilmington, Del., or as now known, the Harlan & Hollingsworth Co., built for the Bangor Steam Navigation Co., of Maine, the "Bangor," a vessel of 450 tons for passengers and freight between Boston, Mass., and Bangor, Me. The frames of this vessel were made of bar iron fastened with iron clamps, and the plating was run in "clinker" built form, in place of the present in-and-out strake form. The vessel was fitted with twin-screw propellers. This was the first iron-hull steamer built for outside service in the merchant marine of the United States. She was 120 feet long by 23 feet beam and 9 feet depth of hold. There were two Loper propellers, 8½ feet diameter each, which were driven by two horizontal engines, each of 22 inches diameter of cylinder by 24 inches stroke of piston. The boiler was 20 feet long, and located in the hold of the vessel. On her second trip from Boston she took fire and was partially burned, but was afterward repaired and continued in the same trade until purchased in December, 1846, by the United States government at a cost of $28,975, and named the "Scourge," about the time of the breaking out of the Mexican war.

The Betts, Harlan & Hollingsworth Company built during the same year two propeller steamboats of 300 tons each for George W. Aspinwall, named the "Ashland" and the "Ocean," both of which vessels were in the service of the United States government during the war of the rebellion, and during which service they were lost. They were similar to those built for the Delaware and Raritan Canal. They also built during the same year the first iron-hull *ferryboat*, named the "Delaware," for the Winnisimmet Ferry Company, of Boston, Mass., of 270 tons, and in 1850 built a duplicate of the "Delaware," named "Winnisimmet," for the same company.

In 1843 and 1844 there was built at the Washington navy yard the iron-hull steamboat "Water Witch" on the plans of Lieut. Hunter, U. S. N. Her length was 100 feet 6 inches long, 21 feet 4 inches beam above the water line, and 16 feet 9 inches below the water line, and 9 feet 9½ inches depth of hold. There were two high-pressure engines, 22 inches diameter of cylinders and 4 feet stroke. She was also fitted with Hunter's submerged wheel, and built for use as a



STEAMER "BANGOR." 1844.

water boat at the Norfolk, Va., navy yard. Proving unsuitable for the purposes originally intended, in June, 1845, a contract was made with R. F. Loper to add 20 per cent to the length of the vessel, and to build other engines, boilers, and machinery to operate Loper propellers. The execution of this work was done by Reanie, Neafie & Co., of Philadelphia, Pa., for the contractor. Prepared for use as a dispatch boat in the Gulf of Mexico, and complaints having been made of her performance, the Secretary of the Navy ordered her to be put out of commission November 6, 1845. In July, 1846, the department authorized the substitution of a new engine and boilers and side wheels, and the addition of materials to strengthen her hull. This was done at the Washington navy yard. In November, 1847, the vessel with these alterations and repairs was in service with the Home Squadron until 1848. In 1850 several of the bottom plates were found to be affected by corrosion for want of paint. In 1851 she was again repaired and a new horizontal tubular boiler fitted. In the same year this boiler was altered by James Montgomery, of Baltimore, Md., but after a trial was condemned as unfit for service. Having been reported "totally unseaworthy" on January 7, 1852, on the 17th of March that year the department authorized her to be rebuilt of pine wood, using the engine then in the vessel. The original cost of the vessel was $53,122, and the alteration to a propeller $37,989. They learned better how to take care of an iron vessel at a much later date, but the learning was expensive and came through experience.

In 1844 there was also built by John F. Starr, at Camden, N. J., a small sidewheel boat of iron named "Independence." This vessel was 90 feet long, 15 feet beam, and 5 feet hold, and had a high-pressure oscillating engine 16 inches cylinder by 6 feet stroke, with one boiler in the hold. The machinery was built by I. P. Morris & Co. She was used for a passenger boat between Philadelphia and Bridgeport, N. J., until about 1850, when all her passenger accommodations were removed and she was put to towing on the Delaware River. Average steam pressure, 75 pounds. At one time she had the name of "W. G. Thomas" on her water-wheel houses, while her original name was on the stern. This was permitted at that early date.

In the same year the Novelty Iron Works, of New York, constructed a small twin-screw propeller named "Albemarle" for service through the canal from Norfolk to North Carolina Sound. This one was similar to those on the other canals. She remained there but a comparatively short time.

Jesse W. Starr, of Camden, N. J., also built same year for the Delaware and Raritan Canal Company the sidewheel tow barge "Camden," about 130 feet long by 20 feet beam. This vessel was entirely of iron including the deck frame, deck, and wheel houses, and was fitted with a square engine.

There was also built by the Novelty Iron Works in 1844 a small sidewheel iron-hull boat of 133 tons, that was taken down and re-erected at Buffalo, N. Y., in the summer of the same year, for the engineer corps of the United States army and named "Abert." The name was changed to "Surveyor" in 1849. The vessel was used for the survey of the northern and northwestern lakes until 1875, was then sold and used as a ferryboat on the St. Clair River.

The propeller "Naugatuck" was built in the same year (1844) for the Ansonia Brass and Copper Company by Henry R. Dunham & Co., one of the large marine engine builders of that day, at the foot of West Thirty-third Street, New York city. This vessel was built to run between New York and Derby, Conn.,

mainly to transport the product of the Ansonia company to the metropolis. The vessel was 105 feet long on deck, 96 feet 8 inches between perpendiculars, 20 feet 4 inches breadth of beam, and 6 feet 8 inches depth of hold; custom-house tonnage 120 50-95 tons. There were two engines with inclined cylinders, each 16 inches diameter by 24 inches stroke, with one boiler, fan blower, and blower engine. The Ericsson screw propeller was 6 feet in diameter. There was a small cabin on deck fitted with 24 berths for passengers. This vessel ran to Derby for about three years, when she was sold to Edwin A. Stevens, of Hoboken, N. J., the Ansonia company building the sidewheel boat "Ansonia" to take her place.

The most noteworthy points in the history of the "Naugatuck" are the experiments made on her by Mr. Stevens in 1857 to test the difference between the ordinary screw and the ordinary paddles of a sidewheel boat, and also to compare the effect produced by each of these with that produced by a single paddle placed in the center and projecting below the bottom of the vessel; and further, her conversion, in the latter part of 1861, into a war vessel, and the alterations and additions made by him to adapt her to that service.

The experiments in 1857 were made at Bordentown on the Delaware River. The draft of water of the vessel was 5 feet, her screw was 6 feet in diameter and had a pitch of 15.29 feet. The side wheels were 10 feet in diameter, and the paddles were 4 feet long and had a dip of 16 inches. The central wheel had the same diameter as the side wheels, but the paddles were twice as long, viz., 8 feet. There was but little difference, either in speed or in effect, between the screw and the paddles; but they were both very far superior to the paddle placed within the hull. This vessel was converted into a vessel of war and presented to the United States government early in 1862. The alterations were the substitution of twin screws for the single screw; the addition of two large tanks at bow and stern to submerge the vessel to a certain extent; the addition of very thick bulwarks of white pine to give buoyancy to the vessel when the deck was submerged, the addition of two rotary pumps to empty the tanks, and the addition of a 10-inch gun placed amidships on deck, pointing in an immovable direction in line with the keel over the bows, but arranged to be elevated or depressed, and recoiling on a stationary carriage against rubber rings. The draft of water with these additions was increased from 5 feet to 7 feet, and the tanks when full added 2 feet 10 inches to her draft, making it 9 feet 10 inches, and submerging her deck 6 inches, so as to flood it to this extent when going into action. The tanks held 3,075 cubic feet of water, and they could be emptied within eight minutes.

The two principles first introduced in naval warfare by the "Naugatuck" were the submerged hull, rendering her to a certain extent "water clad," and the method adopted of traversing the gun, viz., turning the vessel by twin screws upon her own center, thus making this center the pivot of the gun. The "Naugatuck" was turned around by this means in the Delaware River at Bordentown in December, 1861, making a complete turn in three minutes and turning around and around without advancing. The advantage of this method of training the gun by twin screws was shown in the action between the "Monitor" and the "Virginia" and "Merrimac" in May, 1862, when the accuracy of the shots fired from the "Naugatuck" delivered at long range was greatly admired and generally commented upon.

This vessel was in service during the period of the rebellion in the James River and the sounds of North Carolina as a gunboat, and at its conclusion was converted into a vessel for service in the more peaceful pursuits of the revenue marine service. She was thoroughly overhauled in 1871, and again in 1877, and was then mainly employed in Pamlico Sound and Albemarle Sound on the coast of North Carolina. Her draft of water at that time was 5 feet 6 inches. Since her entry into the revenue marine service, her name has been changed to "E. A. Stevens." The vessel was disposed of by the bureau on April 24, 1890, to Henry Brown, of Baltimore, Md.

In 1845 Betts, Harlan & Hollingsworth Company built for Anthony Raybold a sidewheel iron-hull steamboat of 186 x 20 x 7 that was named "W. Whilden." This vessel was afterward altered to a propeller, her name changed to "Gen. Cadwallader," and run through the canal between Philadelphia and Baltimore until 1902, when laid aside from further use.

In the same year Hogg & Delamater, of New York, built at the foot of Jane Street the "Iron Witch" from designs furnished by John Ericsson. Her dimensions were 222 feet 2 inches in length, 27 feet beam, and 10 feet 6 inches depth of hold. The motive power was a pair of inclined engines, each 60 inches by 5 feet stroke, and ample boiler power for a working pressure of 50 pounds of steam. The owners were R. B. Forbes and J. M. Forbes, of Boston, Mass., M. O. Roberts, of New York, and others. This vessel was originally fitted with small side wheels about 16 feet diameter, with the intention to give them a velocity of 35 or 40 revolutions a minute, and thus gain a high speed for the vessel; but the result proved that the highest steam pressure obtained gave only 30 revolutions per minute, and this gave the vessel no advantage in speed over the sidewheel boats then on the Hudson River. The side wheels were after a few months removed, and screw propellers of about 14 feet diameter fitted at the sides of the vessel in place of the radial wheels, and geared for a high velocity. This experiment was found to be "that the last stage was worse than the first," and after several trials the boat was laid up. Subsequently the machinery and propellers were removed, and a vertical beam engine built by H. R. Dunham & Co. fitted in the vessel with the ordinary side paddle wheels, after which she ran as the "Erie" in connection with the Erie Railroad until 1860, when the engine was placed in the ferryboat "Pavonia," now "Rutherford," on the Erie ferry, and the hull converted into a freight barge. The hull was subsequently planked with wood, and was in service a few years ago.

The "Iron Witch" was one of Ericsson's most signal failures. His weakness lay in the fact that the world knew of all his failures, but there were other designers who made as great errors of professional judgment and fact as he, but the world has never been the wiser of the results of their experiments, on account of the secrecy thrown around them. He expected with very small side wheels, high steam, and large engines, with about forty revolutions, to excel any steamboat on the Hudson River in speed.

Otis Tufts, of Boston, Mass., built in 1846 a wrecking tug of 320 tons named "R. B. Forbes" for the underwriters of Boston. She was fitted with a pair of condensing engines, each 36 inches by 32 inches, driving Ericsson twin screws, and two boilers also built by the same builder. She was sold to the Navy Department in 1861 for $52,500, and was wrecked on the coast of North Carolina February 25, 1862.

Jesse W. Starr built for the Delaware and Raritan Canal Company the same year the tow barge "Mars." She was originally about 90 feet long, as the locks on the canal at that time would not permit of vessels over

100 feet in length, but she was afterward lengthened.

In 1845 the Camden & Amboy Railroad Company had built at the yard of Robert L. and E. A. Stevens, at Hoboken, N. J., the iron-hull steamboat "John Stevens" for passenger service on the upper end of their railroad line, from Amboy to New York. A description of this vessel is given in a mechanical journal of 1846: "Her hull is made of the best quality of Pennsylvania plate and rib iron, the plate iron being ¼ inch thick and the rib iron of the angle form, with this difference from the common angle iron, that there is more iron on the top edge and less in the body, just contrary to the common form. The ribs are placed 2 feet apart center to center, except immediately under the engine, where they are 1 foot apart. The size of the ribs is 3½ inches by 2¼ inches, weight 7½ pounds per lineal foot. She has four keelsons of ½-inch iron, with angle iron riveted on top edge. They are 3 feet deep, two of which stand 12 feet apart and are 164 feet long, the ends tapering for the length of 46 feet down to 12 inches in depth, upon which the boilers rest, which stand 41 feet 6 inches apart, fore and aft. The other two keelsons are those upon which the engine rests, being 72 feet long and 3 feet deep in the center for a distance of 24 feet, the balance being reduced to 12 inches in depth. These keelsons are all fastened to one another and sides of the boat by cross keelsons 3 feet deep, and of a distance varying from 3 to 10 feet. She is also provided with a watertight bulkhead of iron 27 feet from the bows, which is a great safety to passengers in case of the bows being stove in, which often happens with great loss of life and property. Being intended for a day boat, and not having been fitted up with berths, her cabins are very airy, light, and roomy.

Length on deck	245 feet
Breadth of beam	31 feet
Breadth over all	65 feet
Depth of hold	11 feet
Diameter of water wheels	31 feet 8 inches
Face of water wheels	12 feet
Dip	2 feet 7 inches
Tonnage	800 tons
Draft of water	5 feet

"Her engine is of that kind known as the 'steeple' engine, improved by the addition of double-connecting rods, with vibrating cross-head which passes through main cross-head, and works upon guides by balance valves fitted with expansion gear to cut off the steam at from ¼ to 2-3 of the stroke of the piston, and also by an improvement in the air pump bucket, which has a circular double opening valve. The engine was made by T. F. Secor & Co., of New York.

Diameter of cylinder	0 feet 75	inches
Stroke of piston	8 feet 0	inches
Diameter of air pump	0 feet 31	inches
Stroke of air pump	8 feet 0	inches
Diameter of force pumps	0 feet 3½	inches

"Boilers of a tubular construction 15 feet long and 12 feet wide, each having 384 tubes 12 feet long and 1¾ inches bore.

"For further safety in case of leakage, she is provided with a bilge injection, of a capacity sufficient to supply the air pump with as much water as it will lift with the ordinary speed of the engine. Also as a further security against damage to the rudder from ice or other floating substances, it is placed under the run of the vessel, the upper edge being 2 feet below the water line.

"The model of this boat was made by Mr. Robert L. Stevens; the drafts of the engine were also furnished by him. We will farther mention that there are many improvements in the details of the hull of the 'John Stevens' that have been introduced by Mr. R. L. Stevens, among which are the peculiar form of the rib iron first introduced on her and since extensively used in England, and the arrangement of diagonal iron braces outside the hull above the water line. Her cost was a little upward of $100,000."

This vessel was burned several years ago, but was afterward rebuilt and fitted with a pair of propeller engines and twin screws in place of side wheels, and has been used as a freight and cattle boat by the railroads in New York waters. In 1903 she was laid aside from further use.

THE Secretary of the Navy in 1843 contracted with Joseph Tomlinson, of Pittsburg, Pa., for the construction of an iron-hull steamer for the United States navy, which was named "Alleghany." The vessel was commenced shortly after the contract was made, but on account of several alterations being made during construction the vessel was not finished until 1847. This was the first iron-hull vessel of war built for the United States navy. Her dimensions were: Length on deck 185 feet, on keel 171 feet, beam on deck 33 feet 4 inches, beam at the wheels 25 feet, depth of hold 19 feet, mean draft 13 feet 6 inches; tonnage 989 tons. About all that can be obtained at this day of the structural part of the hull is that the T-iron was 4 x 5 x ½ inch; and the deck beams of L-iron 7 x 4 x ⅞ inch. The engines had 60-inch diameter cylinders with 48-inch stroke pistons. There were fitted two Hunter's submerged horizontal paddles, placed amidships, 14 feet 8 inches diameter, with paddles 3 feet 6 inches wide and 2 feet 2 inches long. This vessel was in February, 1847, taken down the Ohio River and Mississippi River to New Orleans, and after a short stay at that place was brought around to Norfolk, Va. She was subsequently sent on a cruise to the South American coast, and from there to the Mediterranean Sea, being gone altogether about two years. During this cruise the inefficiency of the Hunter wheel was clearly demonstrated, her best speed while at sea being 7 miles per hour. After being in service but a short time it was found necessary to strengthen her hull by putting in new frames between the old ones. In 1852-53 the Hunter wheels were removed and a screw propeller substituted, and the old engines altered for driving the propeller; and at the same time a Pirsson surface condenser was fitted. The original cost of the vessel ready for service was $242,595, and the alterations made in changing to a propeller cost the sum of $219,000—a very costly experiment for the public treasury.

In 1852 the Harlan & Hollingsworth Company built for the Philadelphia, Wilmington & Baltimore Railroad Company the iron-hull transfer boat "Maryland," for transferring trains across the Susquehanna River between Havre de Grace and Perryville. This vessel was 224 feet by 36 feet 6 inches by 10 feet 2 inches, with two 40 x 96-inch engines. She continued in that service until a bridge was built at that point, when the vessel was laid up. About 1877 she was sold to the N. Y. & N. E. RR. Company and N. Y. N. H. & H. RR. Co. to transfer the through passenger and freight trains from Boston *via* Morrisania to Jersey City, N. J., and *vice versa*. She was destroyed by fire while lying at Morrisania in 1889. The same year they built the "Richard Stockton" for the Camden & Amboy Railroad Company to run in connection with their railroad, from New York to Amboy. This boat had feathering paddle wheels, and was considered above the average in speed.

Reanie, Neafie & Co., of Philadelphia, Pa., built a few iron-hull boats of a small size prior to 1855, but

after that date the number increased, so that of later years they have constructed many iron-hull vessels, some of large tonnage. When R. F. Loper introduced his propeller wheel in 1844 this firm was the first to make the application of the new propelling agency. Then began the propeller contest that lasted for several years.

The Pusey & Jones Company, of Wilmington, Del., commenced building iron-hull steam vessels in 1853, the first being the "Flora McDonald," a small side-wheel vessel for service on the Cape Fear River, North Carolina. Four others were constructed prior to 1861 for domestic service, when they began building for South American waters, and since then have built many steamers for that part of the world, some of good size, both sidewheel and propellers. They subsequently built two steamers for the United States revenue marine, the "Grant," and the "Walter Forward," and two for the United States Fish Commission, the "Fish Hawk" and the "Albatross," the latter a sea-going steamer of 900 tons; and one for the Lighthouse Board, the "Wistaria." They also constructed the "Knickerbocker" and the "Hudson" for Cromwell's line from New York to New Orleans.

The heaviest round iron rolled in this country to the close of 1855 was in that year rolled by the Safe Harbor Works of Reeves, Buck & Co., at Safe Harbor, Pa. Several different-sized bars for piles used in rebuilding of the Brandywine Shoal lighthouse in Delaware Bay, were rolled. Following are the sizes:

5½ inches diameter, 15 feet 6½ inches long, weighing 1,248 pounds.

5½ inches diameter, 24 feet 4 inches long, weighing 1,945 pounds.

6½ inches diameter, 14 feet 5 inches long, weighing 1,617 pounds.

6½ inches diameter, 18 feet 11 inches long, weighing 2,100 pounds.

Iron shipbuilding in the United States is thus spoken of in 1856. "The advantages attending the use of iron as a material for shipbuilding are so many that it is a matter of surprise that up to the present time in this country, they have been almost entirely overlooked. We have on the Delaware a few steamboats where its merits have been appreciated, and the saving by a reduced draft of water in consequence of less weight of hull, is of itself more than sufficient to counterbalance any increased first cost of construction. In addition to this, iron is more lasting. After ten years in a wooden ship, and half that time in a sea steamer, the frames, planking, etc., become so decayed as to be a constant source of expense, and our insurance companies consider eleven years as the *average* duration of timber-built ships. We have but two iron vessels constructed for sea service, the coast survey steamer 'Walker,' and the revenue cutter 'Polk.' These vessels have been in use for eight years, and a recent examination of the former vessel when on the dock did not disclose any symptoms of decay beyond a very slight rust. The bottom plates appear as thick as when first put on, and in fact all that portion of the hull made of iron was in good condition, while the wooden decks and waterways were very nearly worn out. In England the merits of iron are more fully understood, and a wooden vessel there is as rare as an iron one here. Many of the iron shipbuilders are those formerly engaged in timber-built vessels, and in a few years the merchant ships of England will nearly all be of iron. It may be urged that iron is more costly and timber much cheaper here than there. This is true, but yet is not sufficient for the neglect on our part to examine into the matter more fully. Within the last five years the wages of ship carpenters (always in advance of those in England) have advanced. Ship timber of all kinds is now worth more than then, and the price of good timber will be constantly advancing from its increasing scarcity, which has caused for years past the use of inferior material. Copper, which enters largely into the construction of timber-built ships, has in that time advanced twelve cents a pound, or about 50 per cent. While this has been the case with the material used in timber-built vessels, iron has, on the contrary, not advanced, and can at the present time be purchased at a price sufficiently low to enable vessels to be built at a price but little, if any, exceeding the cost of a *first-class* timber-built vessel. But admit that the iron vessel should cost ten or even twenty per cent more than the wooden one, look at the advantages to be gained, viz.:

"*Increased capacity* as to bulk of freight equal to 20 per cent, which, on a ship carrying 5,000 bales of cotton, would make a difference of 1,000 bales, increasing freight money in the same proportion.

"*Safety at sea* from not leaking, and when injured by collision, not sinking, the iron bulkheads preventing this, as in the 'Vesta,' the ship that came in contact with the 'Arctic.'

"*Durability.*—An iron vessel will outlive three wooden ones. Twelve years make no impression on them.

"A timber-built ship has a very great number of vertical and horizontal joints between the planks, where there is no connection, which are filled with oakum to prevent the vessel from leaking, and it is the starting of one of these at sea that causes many a ship to founder, and damages cargo to the amount of many hundreds of thousands of dollars annually. This is an evil inherent in wooden vessels, and nine out of ten suffer in some degree from it every voyage. An iron vessel, on the contrary, has not such a seam in her construction. Every sheet is made to lap its neighbor, and they are firmly riveted together, making the vessel as one piece. The introduction of iron shipbuilding among us would do much toward increasing the consumption of plate iron, and at the same time give to the merchant a better and more profitable vessel."

The greatest defect found in the wooden-hull steamer of this period was the want of watertight bulkheads. After the loss of the Collins line steamer "Arctic," the use of watertight bulkheads began to be much discussed, as the safety of the "Vesta," with which the former collided, proved the worth of watertight compartments in a vessel in case of collision. There were subsequently placed in some wooden-hull steamships iron bulkheads, but these did not always maintain a close joint to the sides of the vessel, the elasticity of the wooden hull being greater than the iron bulkhead.

The first iron-hull steamship for ocean service was the "Champion," built in 1858 by The Harlan & Hollingsworth Co. for Cornelius Vanderbilt. This vessel was a sidewheel vessel of 1,500 tons, and driven by a pair of lever beam engines. She ran from New York to various coastwise ports south of that city for many years. The same builders constructed in the same year a propeller named "Ellen S. Terry," of 400 tons, for coastwise service for Hartford, Conn., parties. This vessel was an early iron-hull propeller in the merchant service, having all the improvements of the day, and was looked upon as the advanced type of freighting vessel of those times. She proved to be a good investment for the owners. Her dimensions of hull were 142 feet by 23 feet by 14 feet, with a condensing engine of 28 inches by 26 inches stroke. The next year they built the "Benj. Deford" and the "S. R. Spaulding," both sidewheel steamships of 1,400 tons

each, for the Merchants and Miners Transportation Company. These vessels were subsequently known as the "San Salvador" and "San Jacinto" when on the New York and Savannah line.

From the time of the building of the "Iron Witch" in 1845 there appear to have been but few iron hulls constructed at New York or the vicinity for several years, the shipyards on the Delaware River having all the work in that line without any break up to about 1860, except it were a few small sidewheel steamboats for South America, and two steamers for coastwise service. These were spasmodic attempts of the marine engine works at New York to compete with the Delaware River yards, that in the end were a failure. The latter yards being close to the iron mills in Pennsylvania, their freight expenses being comparatively small for the delivery of their iron, and the rate of wages being lower also than at New York, was more than the builders at the latter city could contend against in competition for the business.

In 1847 there was built at the works of Mott & Ayres, foot of West Twenty-fifth Street, New York, two iron-hull sidewheel steamboats for the Magdalena River in New Granada, S. A. They were each 150 x 25 x 6, with two high-pressure engines, each 18 inches by 6 feet stroke. They were named "Magdalena" and "Santa Marta." In 1853 and 1854 there was also built at the same works four iron-hull sidewheel steamboats for the Orinoco River in South America. Two of these hulls were shipped in sections, the other two vessels finished complete, and sailed for their destination under their own steam. They were each about 150 feet long.

Boardman, Holbrook & Co., Neptune Iron Works, of New York, completed in July, 1857, an iron hull of 175 x 32 x 8 for the Magdalena River. This vessel sailed under canvas, as the machinery was already in South America—being that of the "Santa Marta" of 1847—and was especially prepared for the voyage. Her name was also "Santa Marta." There were four transverse bulkheads in the vessel with a longitudinal bulkhead built on the main keelson and carried up to the under side of the deck beams, thus making ten watertight compartments.

In the same year Birkbeck & Hodges, marine engine builders, of New York city, built at Williamsburg, opposite New York, in the shipyard of Lawrence & Foulks, the iron hull of the steamboat "Virginia" for the Mississippi Sound Company, of 230 x 35 x 9 feet. The engine was of 48 inches by 12 feet stroke, with two boilers for a working pressure of 35 pounds that were built at their works. This vessel was in service at New Orleans, La. Before this vessel had been ten months in use, and while lying at her wharf, she was totally wrecked by the explosion of one of her boilers, causing the death of seven of her crew. The stop valve upon the branch steam pipe to this boiler was closed, and the safety-valve attachment entangled, misleading the engineers as to the steam pressure, resulting in an overpressure of steam.

The next year Boardman, Holbrook & Co. built another small sidewheel iron-hull steamboat. This was for the Louisiana-Tehuantepec Company, and named "Serchil," for service in Central America. The dimensions of the vessel were 140 feet by 34 feet by 5½ feet, with one longitudinal bulkhead running the entire length of the vessel, which also had three cross bulkheads. The motive power consisted of two inclined engines having cylinders of 18 inches bore and 6 feet stroke.

Samuel Sneeden & Co. in September, 1857, completed at their yard in Greenpoint, New York, the iron-hull steamer "Alabama." This vessel was built for James L. Day, on account of the Lake Pontchartrain Steamboat Line in the Gulf of Mexico, and was the first iron-hull vessel built at the yard of what later became known as the Continental Iron Works, and where the "Monitor" was constructed by T. F. Rowland, who became the junior member of the firm just after the commencement of the work on the "Alabama." The dimensions of the hull of this vessel were 225 x 32 x 9; frames 3½ x 3½ inches; plating 5-16 inch to ½ inch. Motive power was a beam engine by the Morgan Iron Works, having a 50-inch cylinder by 10-foot stroke. In the same year the firm built for A. Poppenhusen and others the sidewheel steamboat "Flushing," having a 3 x 10-foot beam engine built by the Morgan Iron Works. This vessel ran to Flushing, N. Y., until purchased by the United States government in July, 1861, when she was sent south. After a few years' service she was wrecked, but was afterward raised, sent north, where she had a new iron bottom fitted to her hull, and returned south, where she was worn out. The Continental Iron Works now had their yard for several years steadily employed in constructing the monitor type of naval vessels for the United States navy. In 1871 they built for the Union Ferry Company of New York two iron-hull ferryboats, the "Fulton" and the "Farragut." They were fitted each with the inclined engine, so long in use on these ferries. In 1884 they constructed two steel-hull ferryboats for the same company, having beam engines, and named "Atlantic" and "Brooklyn."

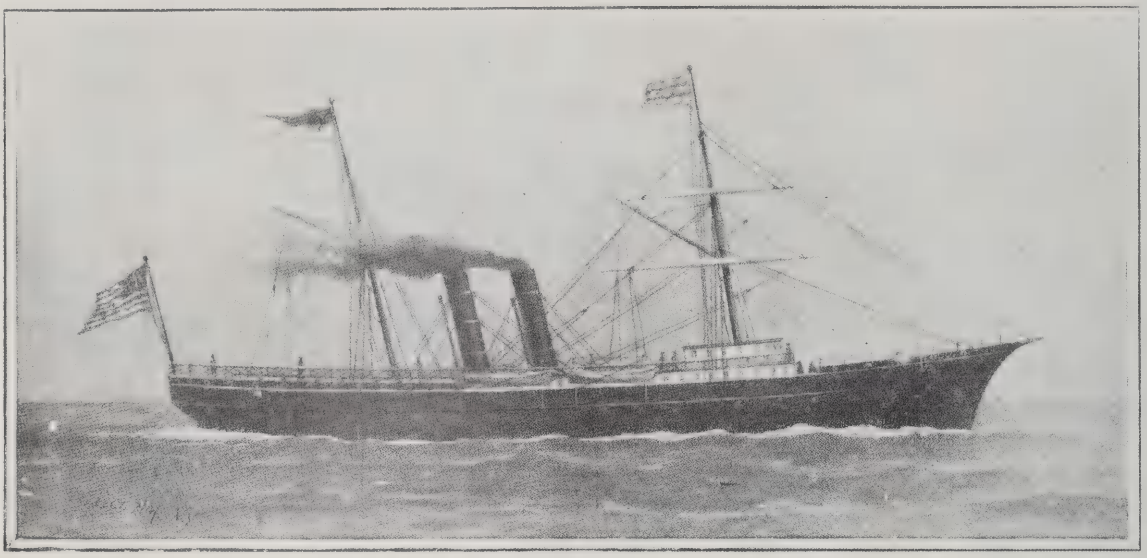
In 1859 C. H. Delamater & Co. built the screw steamer "Matanzas" for the New York and Cuba trade. This vessel was 205 feet by 29 feet 6 inches by 20 feet 9 inches with a loaded draft of 13 feet; frames 3½ x 3½ x ⅝ inch; plating ¾ to ½ inch; double riveted, four athwartship bulkheads. This was the largest iron-hull screw propeller built up to that time in this country.

The next year the Novelty Iron Works built an iron-hull propeller from the design of John Baird, engineer, for H. B. Cromwell & Co. for their Wilmington, N. C., trade, which was named "North Carolina." The dimensions were 172 x 29 x 13 feet with a draft of 9 feet loaded, frames 4 x 3 x ⅜ inch, and plating ½ inch. There were four watertight bulkheads, single riveted throughout. The motive power was a vertical direct-acting condensing engine 42 x 42 inches. The vessel left New York on her first voyage and arrived at Wilmington, N. C., on January 30, 1861, just prior to the outbreak of the civil war, was seized, or otherwise detained there by her southern owners, became a blockade runner, was captured on one of the ventures by the blockade squadron, and subsequently sold by the government and her name changed to "Gulf Stream." She was lengthened about 40 feet in 1868.

In 1856, the iron rolling mills producing most of the plate iron and sheet iron of the country were located mainly about Philadelphia, Pa. There were twenty-five in east Pennsylvania, two at Jersey City, N. J., one at Baltimore, Md., fourteen at Pittsburg, Pa., with one at Portsmouth and one at Cincinnati, Ohio.

Hogg & Delamater built for R. B. Forbes, of Boston, Mass., three small iron-hull steamboats that were shipped to foreign waters at an early date: The "Fire Fly," a screw propeller built in 1846, of 20 tons, that was sent at first to China, and afterward from China during the gold fever to California. The "Mist," built in 1848, of 40 tons, with Ericsson engine, went to San Francisco on bark "Somerset." In 1856 one of 75 tons, no name, sidewheeler, went to China on brig "Rolling Wave."

Boston, Mass.—After the building of the "R. B. Forbes," in 1845, at Boston, Mass., before referred to,



THE "HAVANA" OF 1863.

there were very few iron-hull vessels built for the merchant service in that locality for several years, though there were built there during the civil war twelve monitors and iron-hull tugboats by private parties for government service. There were in papers treating on iron shipbuilding at Boston, statements made of the construction of the iron-hull revenue steamer "Saranac" by Jabez Coney in 1845. This vessel was a *naval* steamer, built *of wood* at the Portsmouth navy yard in 1848, with engines constructed by Jabez Coney. The revenue steamer referred to is more probably the "McLane," already described. In 1858 an iron-hull screw steam yacht was built at Boston for the Pasha of Egypt and named "Voyageur de la Mar." The hull was constructed by Holden & Gallagher, with dimensions of 216 feet by 36 feet 7 inches by 21 feet; floors 6 x 3 inches, with five watertight bulkheads. The motive power was furnished by the Atlantic Steam Engine Works, and consisted of two oscillating engines, each having cylinders 54 inches diameter by 36 inches stroke. The vessel was not a success, on account of insufficient boiler power and too small engines. About the same time the Atlantic S. E. Works built a small sidewheel steamboat of 100 tons named "Argentina," for the survey of the river La Platte in South America; also a small iron steamer of 22 tons that was taken out on the deck of a sailing vessel to the same river. The same builders the next year built another of 70 tons that was sent to China. They also built in 1860 the screw steamer "Pembroke" of 113 feet 6 inches by 24 feet by 9 feet 5 inches, with an engine of 26 x 36 inches. The vessel was sold for a coast guard to the State of Massachusetts, and next year was purchased by R. B. Forbes, who sent the vessel to China, where she was afterward sold. They also constructed the same year four small river steamboats of about 60 feet in length each with side wheels that were sent to the East Indies.

Harrison Loring, of South Boston, in 1858 built the propeller "Sestos" with dimensions of 146 feet 9 inches by 25 feet 8 inches by 14 feet 8 inches, having two oscillating engines each 38 x 32 inches, and three watertight compartments; and the next year the "Contest," of the same general dimensions, both of which were sent to the Hoogly River in India. The same builder in 1860 constructed two screw steamships, the "South Carolina" and the "Massachusetts," each of 1,200 tons, that were afterward known as the "Juniata," and the "Crescent City." They were purchased by the Navy Department during the war, and fitted for the blockade squadron. In 1862 he also built two larger screw steamships, the "Mississippi" and the "Merrimac." They ran for several years on the New York and Brazil line, and also to New Orleans, La.

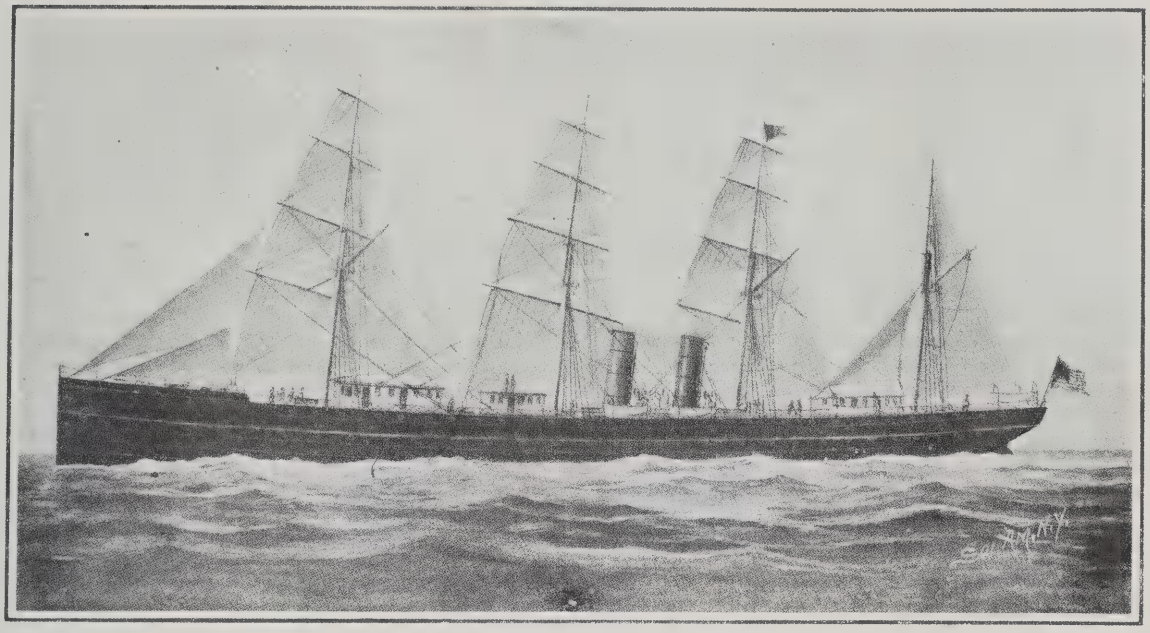
In 1863 the Atlantic S. E. Works built the "William Lawrence" for the Boston and Baltimore line, of about the same tonnage as the "South Carolina."

Of the government vessels built at Boston, Mass., during the years of the rebellion, Harrison Loring constructed the double-ender sidewheel "Winnipeg"; Donald McKay one double-ender and sidewheel, also the "Nanset," a monitor of 700 tons; Nathaniel McKay the monitor "Squando"; Atlantic S. E. Works monitors "Casco" and "Shawnee." The monitors "Chimo," "Wassuc," and the "Suncook" were built there during the same period by other builders.

The Atlantic S. E. Works have built of later years the steel-hull steam yacht "Shearwater," 250 tons, launched May, 1887; the "Unguowa," the "Jathniel," and the "Wild Duck." They also built the revenue cutter "Daniel Manning" in 1897. A number of other steel-hull boats also belong to this period.

III. MODERN SHIPBUILDING PLANTS ON THE ATLANTIC COAST.

The greatest development of our merchant marine, at an early period, was during the decade from 1845 to 1855, with the opening of our coastwise lines with steamships, the building of our large clipper ships, the establishment of our transatlantic steamship lines, and with the hundreds of sailing vessels that were built for service to the Pacific coast during the gold excitement. These were high-water days for our shipbuilders, and advantage was taken of the large demand for vessels. Vast improvements were made in the construction of the vessels, both steam and sail, in a few years, and our builders were acknowledged to be the best constructors of wooden-hull vessels of all the



"CITY OF PEKING," 1874.

maritime nations. There came at the end of the decade many changes, commercial and political, that affected the further development of our merchant marine, and taken in connection with the severe financial panic of 1857 in the United States, proved the beginning of the end of wooden shipbuilding in this country. Then followed a depression in this business, broken for the first period of the civil war, when an increased demand for steam vessels gave it renewed activity for the time being. After 1865 the condition of our merchant marine was worse than that preceding the war. It was now that the question began to be discussed again of wood against iron, for during the 1861 to 1865 period there was no time for discussion of iron hulls, except so far as it related to naval vessels.

When the attempt was made to regain our lost trade on the ocean about 1868 with our wooden-hull side-wheel steamships, it was found that we had lost much ground in the last six years. There had grown up in that time the iron-hull screw steamer until it was no longer an experiment, having proved itself a better vessel in every way than the wooden-hull sidewheeler, having a lower rate of insurance, more economical in operation, and a larger carrier for same size of vessel. When the discussion in commercial circles a few years later turned on the subject of the restoration of the American merchant marine, the iron-hull vessel received much attention. The old discussion of wood versus iron vessels again waxed warm and might have lasted longer than it did, but the compound propeller engine was then in its first stage, and, with its economy of fuel, the comparatively small space it occupied, and the good service obtained from this type of vessel, it soon broke down the barrier of prejudice there was existing among the owners of steam vessels against iron hulls, so that in a few years the days of the wooden-hull vessel were seen to be near a close. In the United States at this period, it was the combination of the iron hull and the compound engine that figured in the rebuilding of our merchant marine, that was employed mainly to ports of the West Indies, South America, and on our coastwise lines, with our large internal steam navigation.

Up to 1860 the building of iron-hull steam vessels had been mainly on the Atlantic coast. The shipbuilding plants at that time, that were equipped with tools of a size to construct a vessel of 500 tons and over, were confined to three on the Delaware River, two at New York, and one at Boston, Mass. Most of these builders were able at the time to contract for the construction of a vessel, with her machinery, within their own plant. The call of the government within a few years for iron-hull vessels in the emergency of war, caused the placing of heavier tools and machinery in the large shipbuilding plants of the period, to produce the heavier class of work demanded at the time. These additions, made for an emergency, became of great value, when iron shipbuilding began to assume a more definite form in the next decade, to those remaining in the business. Prior to this change, however, there had been a leveling process going on. Four or more of our largest marine engine works, some that had built iron-hull vessels, were closed up, and the owners retired from business. With their retirement came the establishment of new iron shipbuilding yards, equipped with more modern tools, and having facilities within themselves to build a vessel entire; to equip and furnish them ready for service and operation. This was the extension of an important industry in this country, and at an opportune moment, for our merchant marine was then in that condition that almost any improvement would be of an advantage over the wooden-hull sidewheeler.

The Delaware River Iron Shipbuilding Company at Chester, Pa., was established in 1871. They purchased the plant previously owned and operated since about 1862 by Reaney, Son & Archbold, who had constructed several iron-hull steam vessels as well as marine engines at these works. John Roach, who became the proprietor under the new order of things, at once began the improvement of the property by the addition

of many large and new buildings, in which were placed improved machinery for the construction of large iron vessels. The first vessel launched from this yard was the steamship "City of San Antonio" on April 5, 1872, for the Mallory line. This was followed by two propellers for the Pacific Mail Steamship Company, the "Colon," and the "Colima;" two ferryboats; and the "City of Waco." During 1874 they built eight ocean steamships, among which were the "City of Peking" and "City of Tokio," of over 5,000 tons each, for the Pacific Mail Steamship Company. In 1875 they completed four vessels, all over 2,500 tons each. In ten years after this date they built fifty-two merchant steam vessels, ranging from 900 to 3,500 tons each, among them being the fleet of the Ocean Steamship Company, Alexandre's line to Havana, Cuba, those of the Old Dominion Steamship Company, three sidewheel boats for the Iron Steamboat Company of New York, the "Pilgrim" for the Fall River line, and several large steam yachts. In 1886 they completed the naval steamers "Chicago," "Atlanta," "Boston," and "Dolphin."

William Cramp, of Philadelphia, Pa., was a builder of wooden vessels up to 1863, when he entered into a contract with Merrick & Sons for the woodwork in the building of a light-draft monitor, the "Yazoo," that was broken up in 1874. In 1865 he equipped his yard for building iron vessels, and the next year he built two iron-hull iceboats for the city of Philadelphia, and with the exception of a few small vessels did not build any of iron until 1870, when William Cramp & Sons built for Thomas Clyde the steamer "Clyde," and in 1872 the "George W. Clyde," having the first compound engine built for a merchant vessel on the Delaware River, and that was successful. J. Shields Wilson was at this time the superintending engineer of the works. In 1872 and 1873 they built the four steamships for the American line from Philadelphia to Liverpool, each over 3,000 tons. They have built many large steamers for the Pacific coast, many large steam yachts, several fine large freight steamers for Morgan's line, and battleships and cruisers for the United States government that have received much notice.

During 1863 the Navy Department made contracts for the construction of seven double-ended gunboats having iron hulls of 255 x 35 x 20 feet, and fitted with inclined engines of 60 inches by 9 feet. These vessels were not completed when the war was closed. Two of them were sold in 1869 to the Clyde Company—one named the "Muscoota"—and finished for the Charleston line. They were named "Georgia" and "South Carolina" by the company.

The Harlan & Hollingsworth Company was established in 1836 under the firm name of Betts, Pusey & Harlan, as car builders. In 1841 Samuel W. Pusey retired from the firm, his interest being taken by Elijah Hollingsworth, and Mahlon Betts retiring from the firm in 1849, when the firm name became Harlan & Hollingsworth, as it has been known of later years. It was not until 1844 that they constructed the "Bangor," their first steamer of iron. They had built two smaller vessels the same year.

During the first fifty years of their business organization they had constructed seventy screw steamers and one hundred and thirteen sidewheel steamers, all of iron. Of later years they have constructed many large steam yachts, several of our largest and fastest sound and river passenger steamboats, as well as many of our large coasting steamships. They can be placed as the oldest iron-hull shipbuilding concern in this country now in operation.

The first iron shipbuilding yard at Baltimore, Md., was that of William T. Malster, afterward Malster & Reaney, who commenced operations in 1876. There had been at irregular intervals iron shipbuilding by the Winans brothers, on their experimental vessels prior to 1860, and several composite vessels constructed by Woodall & Co., yet there was no regular plant devoted to iron shipbuilding prior to the Columbian Iron Works of W. T. Malster. In the first five years of their business they had built three steam tugs, a sidewheel iceboat 200 feet long, the steamboat "Enoch Pratt" for Chesapeake Bay service, and two sidewheel lighthouse tenders, the "Holly" and the "Jessamine." In the spring of 1888 they completed two of the largest steel-hull ferryboats then built for New York waters, the "Erastus Wiman," and the "Robert Garrett." In 1890 they built the first iron-hull tank steamer in the United States. It was used for transporting oil in bulk by the Standard Oil Company.

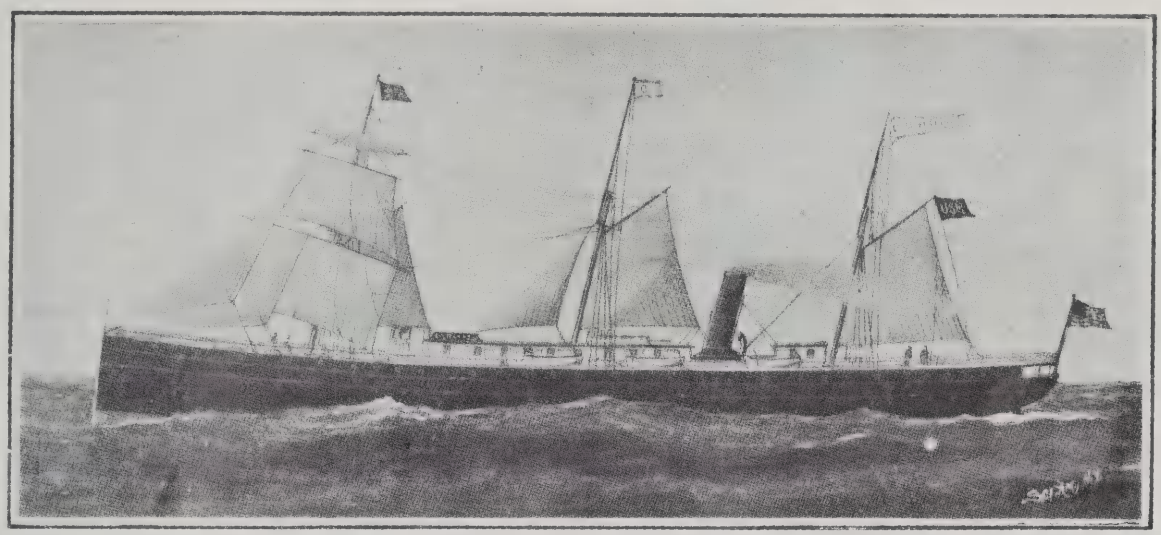
Ward, Stanton & Co., of Newburg, N. Y., began the work of iron shipbuilding in 1876, their first vessel being a steam lighter for Central America. They subsequently constructed several large steam yachts, the "Polynia," "Henrietta," "Radha," and "Namouna," besides several ferryboats and many large tugs. About 1885 this plant passed into the possession of James Bigler, who did considerable work until 1889, when the machinery and tools of the plant were sold to the Chesapeake Dry Dock Company at Newport News, Va. In 1890 Thomas Marvel & Co. became the proprietors of the drydock at Newburg lately operated by Ward, Stanton & Co., and with additional facilities for the prosecution of the business, have conducted an iron shipyard that has produced many medium-size vessels, for passenger, ferry, and freight service, of the first class.

The American Shipbuilding Company, of Philadelphia, Pa., was established in 1883. H. H. Gorringe, formerly of the United States navy, was president of the company, and J. F. Tams secretary and treasurer. This company built a few steam vessels, and one large sailing vessel, and a few small sailing vessels, when financial difficulties overcame them, in three or four years, and the business was closed up.

The Bath Iron Works, of Bath, Me., was established in 1883 as a marine engine works, but it was not until 1890 that the plant was increased to construct iron and steel vessels. Their first contract was for the construction of two gunboats for the Navy Department, the "Castine" and the "Machias," in April, 1890, followed the next year by a contract for building the armored ram "Katahdin." The largest merchant vessel they have built is the famous steel-hull Long Island Sound steamboat "City of Lowell," constructed in 1894.

The Crescent Shipyard, at Elizabethport, N. J., was opened in 1890. They have built the hull of the ferryboat "Cincinnati" for the Jersey City ferry of the Pennsylvania Railroad Company; the practice cruiser "Bancroft" for the United States navy; and the lighthouse tender "Maple," and many large steel-hull tugboats. In 1894 the works passed into the possession of Lewis Nixon, who had lately been superintendent of construction at William Cramp Ship and Engine Building Company. Since then he has built many large steam yachts, several torpedo boats for the United States navy, as well as one monitor for coast defense, with other work of a similar character up to the time of the financial difficulties in the United States Shipbuilding Company in 1903.

John H. Dialogue was one of the members of the National Iron Armor and Shipbuilding Company that commenced business in Camden, N. J., about 1862. The first vessel they built was the propeller "Lookout," of 35 tons, for W. P. Clyde. This company continued in business not more than two years when financial trou-



"GEORGE W. CLYDE," 1872.

bles overcame them, and their business affairs were closed up in a short time. The firm of Wilcox & Whiting came into possession of the plant. Mr. Dialogue shortly after became a sub-contractor under A. & W. Denmead & Son at Baltimore, Md., in the construction of the monitor "Waxsaw," of 614 tons. About 1872 the firm of Wood & Dialogue, River Iron Works, was formed and their plant located at Kaighans Point, Camden, N. J. In that year the propeller "Frank G. Fowler," of 48 tons, was built. A few years later Mr. Dialogue succeeded to the business of the firm by the death of his partner. The specialty of this yard has been the construction of iron-hull propeller tugboats of large size. He was among the first to adopt the compound marine engine and Scotch boiler in his tugboats, as well as in larger vessels. J. H. Dialogue, Jr., succeeded to the business on the death of his father about twelve years ago.

The plant at Newport News, Va., was first organized as the Chesapeake Dry Dock and Construction Company in July, 1889. Controlling the Simpson drydock in the immediate vicinity, the company was reorganized in April, 1890, as the Newport News Shipbuilding and Dry Dock Company. Their first vessels were in 1891, the tugs "El Toro" and the "Dorothy," the latter having quadruple-expansion engines; and in 1892 the Morgan line propellers "El Norte" and "El Cid." They have since built many large coasting steamships, as well as several battleships and cruisers for the United States navy.

Among the largest of the more modern plants on the Atlantic coast is the Maryland Steel Company at Sparrows Point, Md. The shipyard of this company was opened in February, 1890, and during the next four years built the steamers and steamships "Lancaster," "Alabama," "Gloucester," and "Tivoli." The yard was then closed on account of the depression in the shipbuilding industry until 1898, when the "Chester W. Chapin," for the New York and New Haven line, was taken in hand during the next year, which was succeeded by three torpedo-boat destroyers, two cargo steamers for the Boston Towboat Company, and in 1902 by the "Shawmut" and the "Tremont," of 9,600 tons each, for the Boston Steamship Company.

The last metal-hull vessel built at New York city was the "New Yorker." This steel-hull vessel was built for the New York Fire Department in 1890, at the Johnson Foundry and Machine Company at 118th Street and Harlem River.

The New York Shipbuilding Company at Camden, N. J., was organized in March, 1900, and the first vessel launched from this yard was the "M. S. Dollar" on May 4, 1901, for the Robert Dollar Company, of San Francisco, Cal.

The United States Shipbuilding Company was incorporated June 17, 1902, through the consolidation of the Samuel L. Moore Son & Co., the Crescent Shipyard, the Union Iron Works, San Francisco, Cal.; Bath Iron Works, Hyde Windlass Company; Eastern Shipbuilding Company; Harlan & Hollingsworth Company, Canda Manufacturing Company.

The Fore River Ship and Engine Company at Quincy, Mass., was fitted for building steel vessels in 1898. Their first contract was for light vessel No. 72, followed by torpedo destroyers "Lawrence" and "McDonough." They also built later the cruiser "Des Moines" and the battleships "New Jersey" and "Rhode Island," with passenger and freight boats for Long Island Sound service in 1904.

The Eastern Shipbuilding Company at New London, Ct., was organized in 1900. The Burlee Dry Dock Company at Staten Island, N. Y., was established about 1898 for iron shipbuilding.

NORTHWESTERN LAKES.

When the first iron-hull vessel was built on the Northwestern Lakes, the wooden shipbuilders in that section gave but a passing notice to the innovation, thinking it but a fancy of the owner to have a vessel different from the prevailing type on the lakes. Another was built a few years later, and yet not much more consideration was given the subject, though it was known they were profitable vessels for their owners. A few years later and the construction was begun of four larger iron-hull steamers of an improved type for the lake service. Then it was the wooden-hull shipbuilders began to see the drift of opinion in

favor of the iron hull, that was taking the same course as on the Atlantic coast. The war was now on, between the wooden hull that had held its own for so many years, and the iron hull that had demonstrated its superiority of a profitable vessel. The same arguments were used as in a similar case of construction on the coast, but it was no use after a few years, for the iron hull was silently and effectually gaining ground in the whole country.

But the wooden shipbuilders were not compelled to close their yards for several years for the want of orders, from the competition of the iron hull. What was the main factor in closing them at a later period to a great extent, was the scarcity of oak timber for building the vessels. The conditions that prevailed—that there were no large iron-hull steamers constructed on the lakes from 1873 to 1880, and that for a period of six years, from 1874 to 1879, there were built on the lakes thirty-three wooden-hull steam vessels of over 500 net tons each, aggregating 37,201 net tons, and the largest 1,927 net tons—show the hold the wooden hull still had on the vessel owners of the lakes. Local conditions of shoal navigation no doubt had its effect. This consideration for the wooden hull continued almost to the opening of the steel era on the lakes.

On the Northern Lakes iron shipbuilding was first brought into practice by David Bell, of Buffalo, N. Y., in the construction of the screw-steamer "Merchant" in 1861 for J. C. & E. T. Evans, of Buffalo, for lake service. This vessel was 200 feet long by 29 feet beam by 18 feet 6 inches deep, and fitted with a direct-acting condensing engine of 40 inches by 36 inches. The plate iron for this vessel was rolled by Pratt & Co., of the Buffalo Iron and Nail Company, and with the exception of the angle bars and bulb beams that were rolled in Philadelphia, Pa., the entire construction of the vessel was of Buffalo material and manufacture. The hull of this vessel was lengthened 40 feet in 1871, and she continued in service until October 6, 1875, when she was wrecked on Racine Reef in Lake Michigan. He subsequently built the "Philadelphia" of 1,500 tons, for the same parties. There were built of iron at this yard, up to 1870, four tugs, two side-wheel steamboats each about 250 tons, two steam yachts, and two steam revenue cutters. From 1870 to 1884 there were nine steam yachts, three tugs, one steam revenue cutter, and a propeller of 300 tons. David Bell first came to Buffalo, N. Y., in 1845, soon after which time he opened a machine shop.

The King Iron Works in 1871 commenced the construction of four iron screw steamers for the Anchor Line. They were of 1,200 tons each, and named "India," "China," "Japan," and "Alaska." They built the next year the "Cuba," "Russia," and "Java," of 1,500 tons each, and in 1873 the "Scotia," of the same tonnage, and the "Arabia," of 1,200 tons. These vessels were built by Gibson & Craig as sub-contractors.

The Union Drydock Company, of Buffalo, had long been builders of wooden propellers of the largest dimensions in the lake service, but the managers of the company, seeing the trend of the times toward iron hulls, in 1881 equipped their already extensive works with a plant for building iron-hull vessels. Their first vessel, finished in 1882, was named "H. J. Jewett," of 1,953 tons, for the Union Steamboat Company, of Buffalo, N. Y.; and in the same year they completed two tugs. In 1883 they constructed the revenue cutters "Fessenden" and "Perry." The first *steel* hull built at this yard was the "Tioga" in 1885, followed by the "Susquehanna" in 1886.

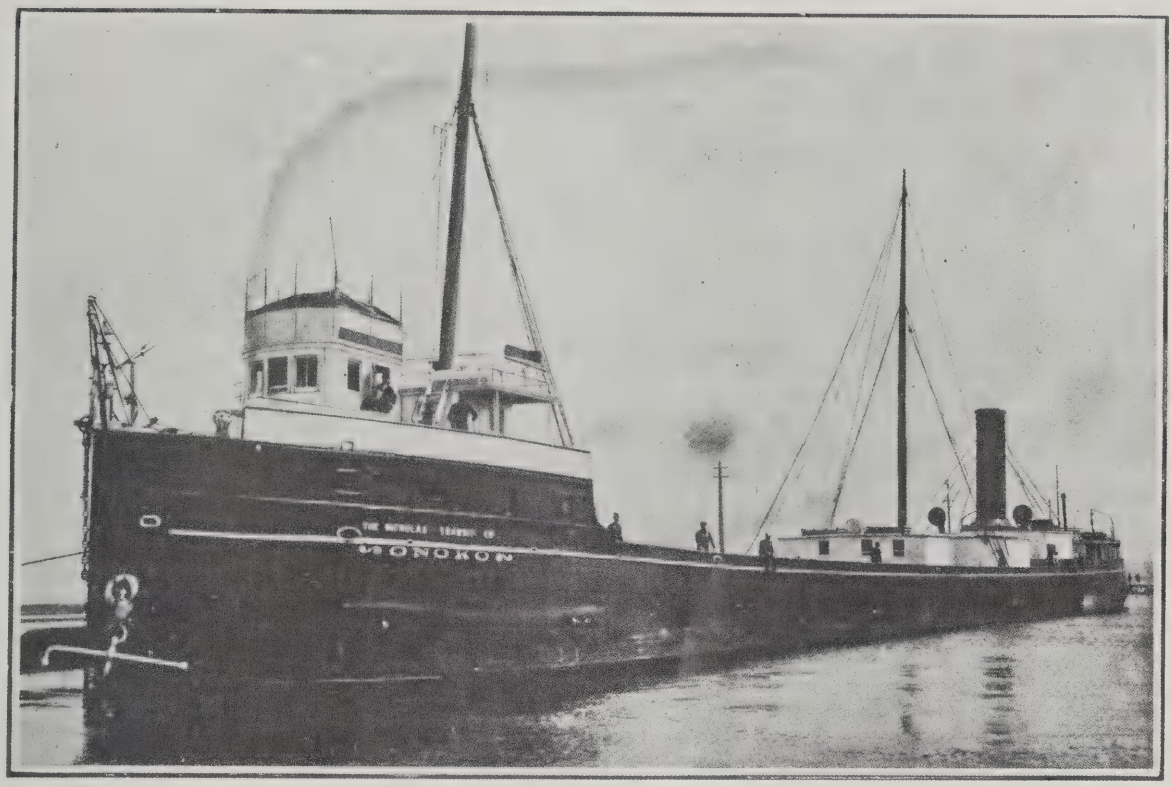
The Wyandotte yard of the Detroit Drydock Company was opened for business in 1871 by Capt. E. B. Ward, who had associated with him F. E. Kirby, an engineer of marked ability. The first vessel launched from their yard was the "E. B. Ward," a propeller of 150 x 26 x 14 feet, which, after a few seasons' service on the lakes was sold and sent to the Gulf of Mexico. In the next two years they built the "Queen of the Lakes" of 260 tons; screw tug "Sport," of 86 tons, having a steel-plated hull, for Capt. E. B. Ward; and the propeller steam yacht "Myrtle." Then the financial panic of 1874 came on, when the industries of the country were paralyzed for three or more years. The ownership of this yard was consolidated with the Detroit Drydock Company in 1877. The next year they built the "City of Detroit," composite hull of 1,094 tons, and in 1879 the "Idlewild," of 312 tons. In 1880, when the revival in shipbuilding struck the lake section of the country, they received their share of the contracts. In this year they built the "City of Cleveland," the "Transport," the propeller "Boston," of 1,829 tons, for the Western Transit Company, the largest vessel they had built to that time, also the propeller "Lehigh," of 1,704 tons, for the Erie and Western Transit Company; and the next year the "Brunswick," "Clarion," and "City of Milwaukee," all iron propellers, and in 1882 the "Michigan," and the "Wisconsin," of 1,200 tons each, having double bottoms 3 feet deep, the first of that type built at this yard. Then in 1883 the "City of Mackinac" for the Detroit and Cleveland Steam Navigation Company, the transfer steamer "Michigan Central," and Grand Trunk Railroad transfer steamer "Lansdowne." In 1884 the *steel-hull* propellers "Albany" and "Syracuse," for the Western Transit Company, of 1,900 tons each. These were the first steel hulls built on the lakes since the tug "Sport" was constructed at the same yard eleven years before. In 1885 the "City of Cleveland," of 1,900 tons, and the twin-screw steamer "Verona," both of steel.

The Chicago Shipbuilding Company, formed of interests in the Globe Iron Works and the Illinois Steel Company, was organized in December, 1889, and the following July the keels were laid of the two steel-hull propellers, the "Masaba" and the "Mariana," of 2,400 tons each, constructed for the Minnesota Steamship Company.

F. W. Wheeler & Co., who had been building for several years wooden-hull vessels for the lakes at West Bay City, Mich., in 1888 fitted up their yard for constructing iron and steel hull vessels, and on March 18, 1890, launched their first steel vessel, the sidewheel passenger steamer "City of Chicago," for Graham & Morton, of Benton Harbor.

The Cleveland Shipbuilding Company was organized by taking over the Cuyahoga Steam Furnace Company's Works and a drydock company. The former plant was built in 1836 to manufacture steam engines at Ohio City, and had a furnace at Dover. Their original plant was driven by a 12-horse-power high-pressure engine built by P. B. Andrews, of Cleveland, Ohio, who was about the largest builder of marine engines for lake vessels of that period. The Cuyahoga Company also built several marine engines. The Cleveland Shipbuilding Company equipped their works with modern tools for iron and steel shipbuilding in 1887, and the next year built the steel-hull steamer "Lackawanna," and car ferry steamer "Transfer," and in 1889 the "Scranton" as a mate to the "Lackawanna."

The American Shipbuilding Company was organized in April, 1899, by the consolidation of the Cleveland Shipbuilding Company, the Globe Iron Works Company, Shipowners' Drydock Company, Chicago Ship-



THE "ONOKO," 1882.

building Company, Superior Shipbuilding Company, Detroit Shipbuilding Company, and the Milwaukee Drydock Company.

The Globe Iron Works, of Cleveland, Ohio, had been for many years constructing engines and boilers for lake steamers on a large scale, and in 1880 the owners prepared to extend their plant sufficiently to include the construction of iron hulls, and thus be able to complete a contract for an entire vessel within their own works. In 1881 they began the construction of their first iron vessel, and in the spring of 1882, the "Onoko," as she was named, was launched. As this vessel was the pioneer of an advanced type for lake navigation, a radical departure from anything then in service on those waters, a few items of detail of the vessel may be of interest. Dimensions of hull 288 feet between perpendiculars, 39 feet beam, 25 feet from spar deck to base line, with double bottom for water ballast. Tumble home, topside at plankshear 8 inches. Keel 11-16-inch iron; angle iron 3 x 3½ x ⅜ inches; floor plates, 5-16 inch; one main keelson ⅝ inch, 3 feet 9 inches high, continuous fore and aft, and fastened to keel by angle irons 4 x 4 x 7-16 inches. Three side keelsons on each side of main keelson of same height as the latter, and spaced 4½ feet apart; they support the deck of the double bottom, and are made of ⅜-inch iron. The double bottom extends from collision bulkhead to engine bulkhead, having a capacity of 700 tons of water, and is divided into six compartments by transverse bulkheads. Plating, in-and-out strakes, 9-16-inch iron from keel to lower deck, then ½-inch, and sheer strake ⅝ inch. Beams of lower deck bulb T-iron 10 inches deep, and upper deck 8 inches. There were originally two firebox boilers, each 18 feet long and 8 feet 8 inches diameter, tested for a working pressure of 100 pounds of steam. One fore-and-aft compound engine having cylinders 30 inches and 56 inches by 48 inches stroke, with cranks set at right angles, placed well aft in the vessel. This was the pioneer all-iron freight boat, and was something of an experiment on the lakes at the time, but she fully sustained the promises that were made for her of a serviceable and economical boat in operation, and a good paying vessel for the owners.

These builders constructed further but few iron vessels, a small sidewheel vessel and two tugboats, as the steel-hull era set in so soon after their establishing a shipbuilding plant that their construction of vessels has been almost entirely since of steel.

The Globe Iron Works was purchased by a syndicate of Cleveland capitalists in 1886, and the name of the corporation changed to Globe Shipbuilding Company.

WESTERN RIVERS.

There were no iron-hull vessels constructed on the western rivers after the building of the naval steamer "Alleghany" in 1847, until the iron-hull monitors were built for the U. S. navy during the rebellion. The abundance of ship timber and its low price in the western States, with the elasticity of the light wood frame of these river steamboats, that must in many cases in their navigation run over very shoal places, and often touching the bottom of the river, gave the preference to the wooden hull. The additional cost of original construction was a factor of no small moment, that prevented the development of the iron-hull steamboat on the western rivers.

During the civil war the United States government contracted for the building of eighteen iron-hull mon-

itors in the middle western States. Of these, eight were built at St. Louis, Mo.; five at Cincinnati, Ohio; four at Pittsburg, Pa., and one at Mound City, Ill., the largest being the "Tippecanoe," "Catawba," and "Oneota," of 1,034 tons each. Of these eighteen vessels, but seven were completed prior to the close of naval operations on the western rivers. The "Winnebago" and the "Chickasaw" were in the engagement in Mobile harbor on August 5, 1864, under Admiral Farragut, and these two vessels took a prominent part, with the other ironclads, in the battle with the rebel ironclad ram "Tennessee," and did good service. In 1877 the hull of the "Winnebago" was altered to a stern-wheel freight boat and named "Charles P. Chouteau," and after being lengthened was 296 x 54 x 8 feet. In 1881 the "Chickasaw" was altered to a side-wheel transfer boat.

There was no further construction of iron-hull vessels on the western rivers until the Iowa Iron Works, of Dubuque, Iowa, the builders of the torpedo boat "Ericsson" in 1893 for the U. S. Navy Department, built the steamboat "Clyde" in 1869-70. This was the first iron-hull steamboat built in the West since the "Valley Forge" of 1840, and she was 135 x 19 x 4 feet, with two high-pressure engines, each cylinder 12 inches diameter and 78 inches stroke, with two flue boilers. The vessel was subsequently altered to a sternwheeler, and is still in use. In 1872 they built the "J. G. Chapman," a sternwheeler, of 125 x 20 x 4 feet, with similar machinery to that of the "Clyde." Then for several years there were no iron hulls built at this yard, but with the advent of the steel era in shipbuilding a change took place, and there has since been more activity in the construction department at these works.

The Western Iron Boat Building Company at Carondelet, Mo., was established in 1874 by Charles P. Chouteau, of St. Louis, Mo. The latter was also largely interested in the Laclede Rolling Mills, of that city, that furnished a large amount of the plate iron for several of the monitors built in the western States. This shipbuilding plant was originally run under the management of Theodore Allen, an engineer from New York city, who subsequently, with A. H. Blaisdell, became the owner. This yard built many iron-hull vessels for the western rivers: In 1874 the snag boat "O. G. Wagner;" in 1875 the sternwheel tugboat "A. G. Humphries;" in 1876 tugboat "W. J. Florence;" and in 1877 tugboat "Bessie," freightboat "Charles P. Chouteau" (monitor "Winnebago") and the twin-screw propeller "Indianola" as a U. S. mail boat; in 1878 four sidewheel U. S. survey steamers; in 1879 the sidewheel snagboat for the U. S. government, "H. G. Wright," whose dimensions were 187 x 62 x 8 feet. The next two years they built two snagboats, two survey boats, and two propellers. In 1881 they altered the monitor "Chickasaw" to a sidewheel transfer steamboat named "Gouldsboro," for the Texas & Pacific Railroad Company, and the vessel is still in use. The hull of this vessel was used as a lighter to transfer coal to steamships at sea, prior to the jetties being built at the mouth of the Mississippi River. During the same year they built two iron-hull towboats 175 feet long each, for the Mississippi River Improvement Commission. The company subsequently went out of business, the machinery and tools being removed to the yards of Edward Howard at Jeffersonville, Ind., where there have been some steel vessels built of later years. The Western Iron Boat Building Company introduced into some of the vessels built at their yard the longitudinal system of framing, but its increased cost prevented many owners of steamboats from adopting it in construction.

Iron shipbuilding was also carried on by M. A. Sweeney at Jeffersonville, Ind., and by the Springfield Boat and Manufacturing Company at Springfield, Ind., and the American Boat Building Company at St. Louis, Mo.

There was no further construction of iron-hull vessels on the Ohio River until 1871, when Alexander Swift & Co., of Cincinnati, Ohio, who had an iron rolling mill on the Ohio River, and had built three of the iron-hull monitors for the western rivers, constructed the sternwheeler "John T. Moore" for the Red River service. The hull was originally 191 x 42 x 7 feet, and fitted with two engines, each having cylinders 22¾ inches by 6 feet stroke. In 1881 the vessel was purchased by the Texas and Pacific Railroad Company and altered to a sidewheel transfer boat, and name changed to "Endeavor." In 1883 the hull was lengthened about 40 feet, and the vessel was continued in service to 1901. In 1873 the same builders constructed the "Alexander Swift" as a towboat for their own use. The hull was 151 x 28 x 5 feet 7 inches with two engines 21 inches by 7 feet. This vessel was subsequently sold to W. H. Brown & Sons, coal operators at Pittsburg, Pa., and in 1891 the vessel was lengthened 27 feet and name changed to "Mariner," and is still in service.

PACIFIC COAST.

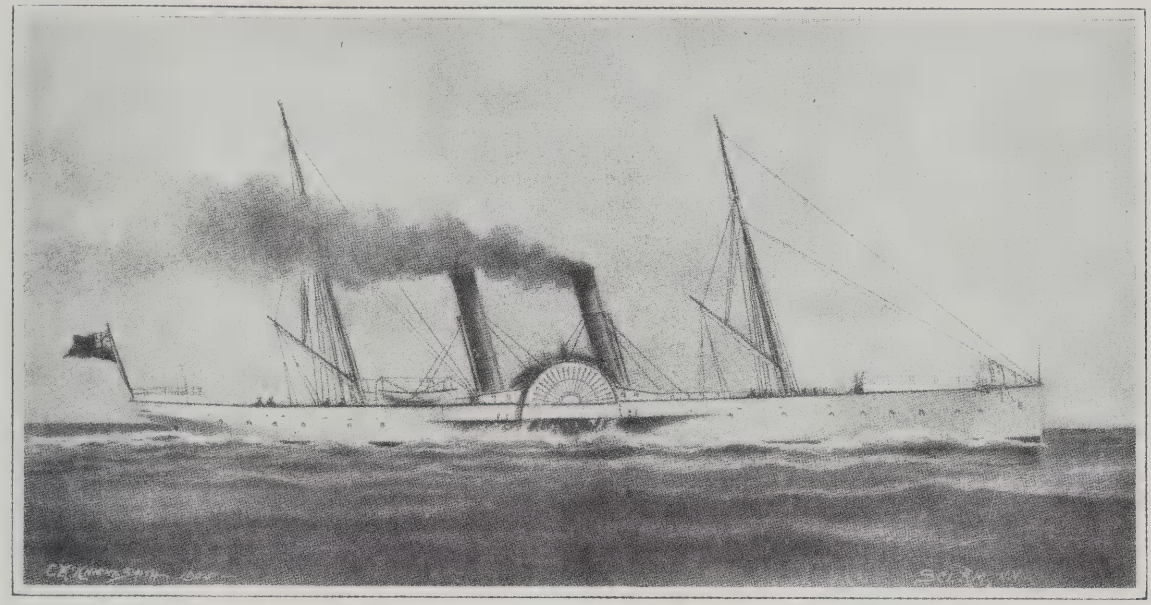
Iron shipbuilding on the Pacific Coast was inaugurated by the opening of the Union Iron Works at San Francisco, Cal., in 1884, in the construction of a steam collier for the Pacific Coast. They built but very few iron hulls, as the age of steel had well progressed before they were in active operation. There had been a few iron vessels wrecked on that coast, which had received very extensive repairs at the Risdon Iron Works in San Francisco, prior to 1884, but there were no new iron vessels constructed on that coast until the date named.

STEEL SHIPBUILDING.

BLOCKADE RUNNERS.

The first hull of a steam vessel where steel plate was used in its construction, in this country, is known to have been built in 1873, but it is not so well known that the U. S. navy had *all-steel* and *steel-plated* steam vessels in its service many years before this date. These vessels were forced contributions to its service during the civil war of 1861-65; otherwise, they were captured blockade runners. Not all these vessels were taken into the naval service, for several were purchased by parties for the merchant service at the same period. They were all built in Great Britain, mostly at Liverpool, while a few were built on the Clyde River in Scotland.

The first eighteen months of the war, the vessels that were sent out to run the blockade of the southern ports were of a very indifferent type of vessel for the risk; but as the blockading fleet became larger in numbers, and more efficient in the duty assigned them, it was found necessary to have a different class of vessel from any then engaged in breaking the law. Accordingly, vessels were designed of lighter construction and higher speed, expressly for the purpose of running the blockade. Steel plate had been used for a few coastwise and river boats before this in Great Britain, and it was now determined to make use of this then untried metal in the construction of a sea-going steamer. The first vessel that was laid down for this



BLOCKADE RUNNER "BANSHEE."

special service, and built of all steel, was the "Banshee," constructed by Jones, Quiggins & Co., of Liverpool, and completed in May, 1863. The vessel was 214 x 20 x 8 feet loaded draft, and fitted with two oscillating engines, feathering paddle wheels, and two boilers. The shell plating of the vessel was ⅛ inch and 3-16 inch thick. The manager of the fleet to which she belonged says: "Considering how frail the vessel was, the wonder is, not that the 'Banshee' was driven back (in a heavy storm), but that she ever got across the Atlantic at all." This vessel was the first of a fleet that soon became famous, and was the first steel vessel to cross the Atlantic Ocean. This vessel was captured November 21, 1863, purchased by the Navy Department March 12, 1864, after the captive had passed through the prize court, and fitted out as one of the blockading fleet. The service was limited, as most of the time the vessel was at the machine shops for repairs. She was sold after the civil strife was over by the Navy Department and placed in the merchant service, the name being changed to "J. L. Smallwood." The last known of her under the American flag was as transporting cattle in the Gulf of Mexico to the island of Cuba. She subsequently passed into foreign hands, and was known as the "Irene" in the Bahama Islands. That seems to be the record of the first steel steam vessel under the American flag, though of foreign build.

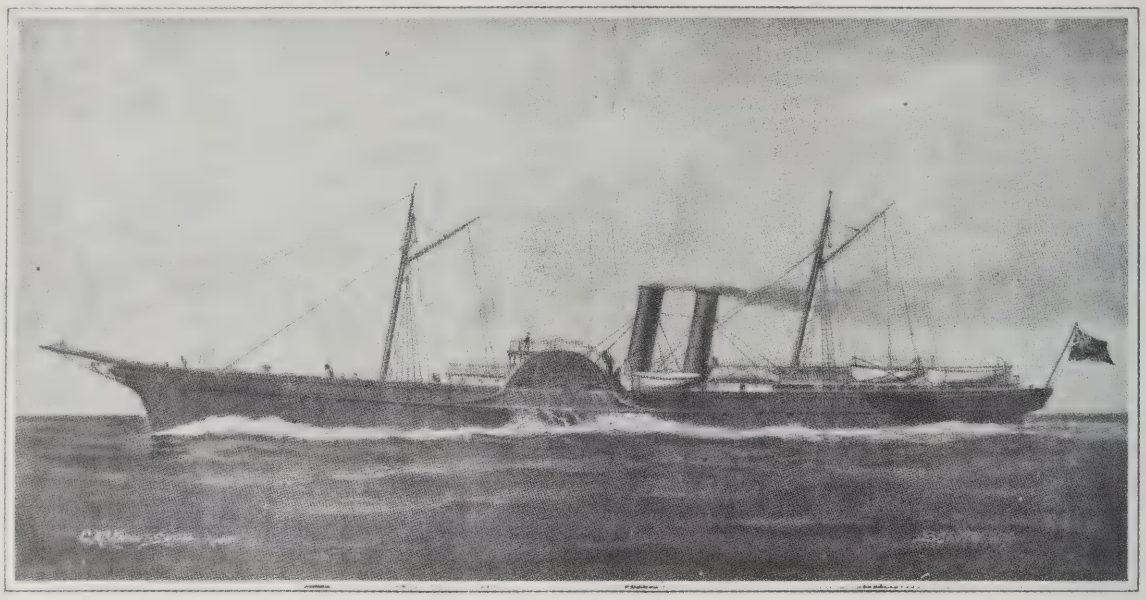
The Navy Department had another of the same type of vessel in its service, named originally the "Bat." This vessel was constructed by the same builders in 1864, and was 230 x 26 x 9 feet 6 inches, with a loaded draft of 6 feet 6 inches. The motive power was two oscillating engines, each having cylinders 52 inches by 4 feet stroke. This vessel was captured October 16, 1864, with a cargo mainly of machinery. The Navy Department purchased this vessel, fitted her with a light gun battery, and assigned her to the blockading fleet. She was subsequently sold, entered the merchant service, and for two or three years run in the coastwise trade under the name of "Teaser." This vessel and some other ex-blockade runners were subsequently altered to towboats for the lower Mississippi River.

There was also the "A. D. Vance," steel plated, built on the Clyde by Caird & Co. as the "Lord Clyde" in 1862, with dimensions of 236 x 26 x — feet. After her capture the vessel was purchased by the Navy Department in September, 1864. This was a larger and more substantially built vessel than those previously named. She was taken into the blockading fleet as the "Advance," and after the war name changed to "Frolic." She was on the European station, and in the South Atlantic squadron, and was sold when the unserviceable vessels of the navy were disposed of in 1883.

The "Lillian" was another of those steel vessels built on the Clyde in 1864, and was a very fine vessel for the special service of blockade running. She was captured in the summer of 1864, and the Navy Department having purchased the vessel, fitted her with a light battery, and placed her in the blockading fleet off Wilmington, N. C. She was sold at the close of the war, put in the merchant service in the Gulf of Mexico for a few years, and at a later period she was found as the "Cespedes" in a Cuban filibustering expedition, in company with that well-known filibustering vessel of that time, the "Cuba," ex "Hornet," and ex-blockade runner "Lady Sterling." The latter was taken after her original capture in 1864 and fitted up handsomely as President Lincoln's yacht, so called at the time. She was sold by the Navy Department about 1867, and shortly after her illegal service was begun. She was in the "lime light of publicity" in 1869, through her operations in the cause of Cuban independence, and gave the U. S. government much trouble at the time to see that her owners did not transgress the neutrality laws of the country. She was not the only vessel the authorities were compelled to closely watch at the time.

There were many captured blockade runners having all-iron hulls, and taken into the naval service during the civil war, but none having steel in their construction originally, so far as the record shows, except those named. If there were others, all trace of them appears to be lost.

It is not known just how many of these steel vessels



BLOCKADE RUNNER "A. D. VANCE."

were constructed for this special service; but it cannot be an exaggeration to say there were forty at least of them built. The Liverpool builders constructed up to 1866 sixty steel-hull vessels, steam and sail. The steel plate mainly used in building these vessels was rolled from ingots made by Henry Bessemer & Co., steel manufacturers, by Marriott & Atkinson, of Sheffield. At first the frames of these vessels were of so light material that with their large engine power the hulls were strained very badly when the vessels were put to the top of their speed, as they often were on being chased by some of the blockading fleet. They have often arrived at their destination with the seams of the plating of the underbody opened so much, that it was with difficulty that the pumps kept the vessels afloat. The later vessels were mostly larger and built of heavier material, and of more comparative engine power than those constructed at first.

But few of this higher class of vessels fell into the hands of the blockading fleet. The finest of this fleet of vessels was the "Col. Lamb," the property of the Southern Confederacy. This vessel was built by Jones, Quiggins & Co., late in 1864, and was a paddle-wheel steamer of 281 x 26 x 11 feet, fitted with two oscillating engines, and the hull divided by four water-tight bulkheads. On her trial trip, in a two-hour run, she made 16¾ knots, or 19.3 miles per hour. This vessel was the greatest development of the blockade runner of that period. The machinery for the "Bat," the "Col. Lamb," and the "Owl," another one belonging to the Southern Confederacy, was constructed by Laird & Co., of Birkenhead, and had each two oscillating engines with cylinders of 52 inches diameter and 4 feet stroke, operated at a steam pressure of 30 pounds.

Among the steel vessels that were captured, sold by order of the prize courts, and purchased by private parties, were the following: The "Lucy" was placed in the coastwise trade, where she remained for three or four years. The "Tartar" ex "Wren," built by Laird & Co., was sent to the Gulf of Mexico, and ended her career as a towboat on the lower Mississippi River. The "Savannah" ex "Hope," one of the larger type of vessels belonging to the Southern Confederacy when captured, was under charter to the government, and in the merchant service for about five years. There was also the "Palmyra" ex "Deer," and the "Zenobia" ex "Stag," large sidewheel vessels, built at Newcastle, England, that were bought by Boston parties, and run from Boston to the Gulf of Mexico, and subsequently to South America, for a few years, where their record under the American flag closes. There was an all-steel twin-screw propeller of 550 tons, built in 1863 at Hull, England, that became a blockade runner, but under what name she was captured there appears no way of ascertaining at present, though she was launched and in our coastwise service as the "Pelican." There is no steam vessel of that name in the record among those captured by the blockading fleet. The owners of these vessels often resorted to a change of the vessel's name, so as to cover her identity in case of capture. In many cases, the captors have been unable to find on the vessels any papers whatever showing name or ownership, or anything to identify the vessel, they having been thrown overboard when capture became imminent.

In 1864 Laird & Co. built four paddle-wheel steamers having frames and shell plating of puddled steel for the same service, named "Lark," "Wren" (which was captured), "Isabel," and "Penguin. The first two of these were each 211 x 23 x 10 feet 9 inches, and were fitted with oscillating engines of 120 horse-power nominal. The two last-named were each 246 feet 8 inches x 30 x 13 feet, and fitted with same type of engine of 260 horse-power nominal.

The Southern Confederacy, through its Treasury Department, started an opposition line of blockade runners of their own in 1863, composed of five steel vessels similar to the "Banshee," and named "Cerus," "Venus," "Hebe," "Juno," and "Vesta," to bring in the supplies necessary for the army and navy of the Confederacy, and to run out the cotton in bales to Nassau, for shipment to England, to pay for the supplies furnished. These vessels were singularly unfortunate, or otherwise, for they all ran ashore on their first or second voyage. It was claimed at the time that they interfered with the business of those large trading

companies, so called, that had so many vessels in the contraband trade at the time. This would appear to have some ground of truth, for most of the Confederate blockade runners of a later date had Confederate naval officers as commanders.

How these steel-hull vessels were constructed may be seen from the following report as to the condition of the U. S. S. "Bat," then a month or more in the U. S. navy, and but about nine months old: "I would again respectfully call your attention to her. Lying in the smooth water of the James River, she leaked 20 inches in 24 hours. By the settling of the deck amidships, the woodwork has encroached so much upon some of the working parts of the machinery as to necessitate the cutting away of a portion of it. The tubes in the boilers have begun to give out. Twenty in one, and five in the other boiler are now plugged. These and other matters reported by the engineer in charge, have been referred to the fleet engineer. Her decks require thorough calking, some of the seams being nearly three-quarters of an inch wide, with nothing in them."

As further evidence of the frail structural work of many of these vessels, an English engineer of that period said: "There is no doubt that the blockade runner 'Lelia,' which went down off Llandudno last year (1865) with Mr. Thomas Miller, of Liverpool, on board, foundered because of some of her steel plates giving way below the water line. She was strongly framed, but, like all those boats, heavily engined, and her commander, in spite of proper precaution, pushed her ahead against a heavy sea, and thus the very power which would have carried a rigid iron vessel safely through the waves, became her destruction. The powerful engines would, as it were, almost force the framework through the delicate steel shell, causing it to buckle and crumple, and give from the rivets, against the mighty pressure of the waves. Many shipbuilders say, at the present time, that the difficulty of obtaining one hundred or even fifty tons of steel of uniform quality throughout is a great hindrance in many instances to its adoption."

We cannot obtain a better view of the conditions surrounding the use of steel plate in shipbuilding in Great Britain at this early date, than from the opinion given of its use by J. Scott Russell, the noted English naval architect, in 1866: "Most of us have already tried the building of steel ships, and those who have not done so, have been sorely pressed to do so by those who think well of that material. I, myself, am one of those who think well of it, but who doubt whether we yet possess data to enable us to proceed with certainty to build large floating structures, wholly or chiefly composed of steel. I was told by those using steel plates which had a tensile strength of 40 tons to the inch, I should be able to build a ship of half the weight of a ship built of iron plate having a tensile force of only 20 tons to the square inch, and so effect a saving in weight of the greatest importance. I have reason to think that several vessels have been built of steel in the belief that this statement was true, and that a vessel of half the thickness in steel would be as strong as another of double the thickness in iron. But these vessels have, I think, disappointed their builders and owners in several ways not anticipated, and such experiments have discouraged the use of steel unreasonably, for I am prepared to believe that there are cases in which ships of steel would be very valuable, provided we had sound data on which to construct them with certainty. At present the difficulties of steel shipbuilding are more formidable than those of steel engineering."

After 1866 the building of steel vessels fell off, as there had been many disappointments encountered in the use of the vessels, and this bred a want of confidence in the use of steel. The price of steel being much higher than iron, in many cases the lowest quotation secured the order for the material, and in some cases plates of an inferior and brittle quality were furnished. Besides, they passed through the experience of finding that a too high tensile strength had been acquired at an expense of the ductility of the metal. These things, with the higher price than iron plate, were against the further use of steel in shipbuilding at the time, and for the next twelve years there were not more than ten vessels built of steel in Great Britain, and they were of small dimensions. The era of steel here began in 1878, and in that year there were eight steel vessels built of Siemens-Martin steel, and seventeen constructed of Bessemer steel, twenty-five in all.

The first steel-hull steam vessel built in any country, so far as at present known, was that constructed by John Laird, of Birkenhead, England, and completed in February, 1858, for Dr. Livingstone's second expedition to Africa, and named "Ma-Robert." The vessel was a paddle-wheel launch of 75 x 8 x 3 feet deep, with a non-condensing engine. The hull of the vessel, as well as the boiler, was built wholly of Howell's homogeneous metal, or puddled steel, that was something new in the steel plate line at the time in England. These plates were 1-16 inch thick for the hull, and were then thought to be stronger than ¼-inch iron plate for the same purpose; and the maker of this steel plate considered it could be depended upon for a tensile strength of 50 tons. This plate sold at the time for $250 per ton. The vessel was sent out to Africa on board of a vessel in three sections. From all accounts, the wearing qualities of this steel in the hull of the vessel was not of the best, though the vessel, no doubt, had a very hard service to perform on the shoal rivers of Africa. It scaled off on both sides of the sheets in large pieces, so that in a few months after the vessel was in service, the steel plating was in many places not more than 1-32 inch in thickness.

STEEL SHIPBUILDING IN UNITED STATES.

THE manufacture of steel in this country dates from a very early period, but it met with very indifferent success. It was used mainly for tools and agricultural implements. During the period of the civil war in this country, the Bessemer process of steel making was first introduced in the United States. An experimental plant was established in 1862 at Wyandotte, about ten miles below Detroit, Mich., on the Detroit River, by E. B. Ward, adjacent to his extensive Wyandotte Rolling Mills, subsequently called Eureka Iron Company, for the making of steel ingots to roll into rails. The process here used was one invented by William Kelly, of Eddyville, Ky. On account of the delays incident to all new departures in manufacturing, and other causes, the machinery was not completed for the operation of the works until September, 1864, when the first steel made in this country, under what was practically the Bessemer process, was produced. This mill made but a small amount of steel when it ceased operations, and as the experimental steel works under the Bessemer patent commenced operations but a few weeks later, they found it to their mutual interests to form a consolidation in 1866 as the Pneumatic Steel Association. The original Bessemer steel mill under the Bessemer patents in this country was started at Troy, N. Y., by

Winslow, Griswold & Holly, and their first conversion of steel took place on February 16, 1865.

The open-hearth process in the making of steel under the Siemens-Martin patents was introduced in this country a few years later, and was attended, like the introduction of the Bessemer process, with its many discouragements and trials attending a new departure in any process of manufacturing. This process for making steel was first introduced in 1868 by Cooper, Hewitt & Co., of Trenton, N. J., and some time after a few other manufacturers adopted its use. The first plant that was built for the exclusive manufacturing of steel by this process in this country was the Otis Iron and Steel Company, of Cleveland, Ohio, in 1874.

The first vessel built in this country having steel plates in her construction was the propeller tugboat "Sport," of 65 x 14 x 9 feet 6 inches, in 1873 at the Wyandotte shipyard of E. B. Ward and Frank Kirby. The shapes in the vessel were of iron. The steel plating used in the vessel was rolled from some of the ingots left at the time of the closing down of the experimental steel plant at Wyandotte, as previously mentioned. David Bell, of Buffalo, N. Y., plated three small steam yachts he built in 1875 with steel plating rolled at a plate mill in Buffalo.

Steel plate of American manufacture was used at this period for several marine boilers. The first built was in 1870 by the People's Machine and Boiler Works, of Baltimore, Md., for the U. S. revenue steamer "Northerner." In 1872 the owners of the steamboat "Mary Powell," of New York, had two steam boilers constructed of steel for the vessel by Alex. Cauldwell, of Newburg, N. Y.; and the same year Murphy, McCurdy & Warden, of New York, built one boiler of steel for the steamboat "Shady Side" for New York waters. All of this steel was made by Park Brothers Co., of Pittsburg, Pa. The braces, tubes, and rivets were of iron.

The first marine boiler built in this country of steel was that for the steamer "William G. Hewes" of Morgan's line in 1860, by the Morgan Iron Works, of New York city, of English plate steel. The machinery of the vessel was built at the Morgan Iron Works, and the iron hull by the Harlan & Hollingsworth Company. Was intended for service in Gulf of Mexico. Boiler was a flue-return tubular type.

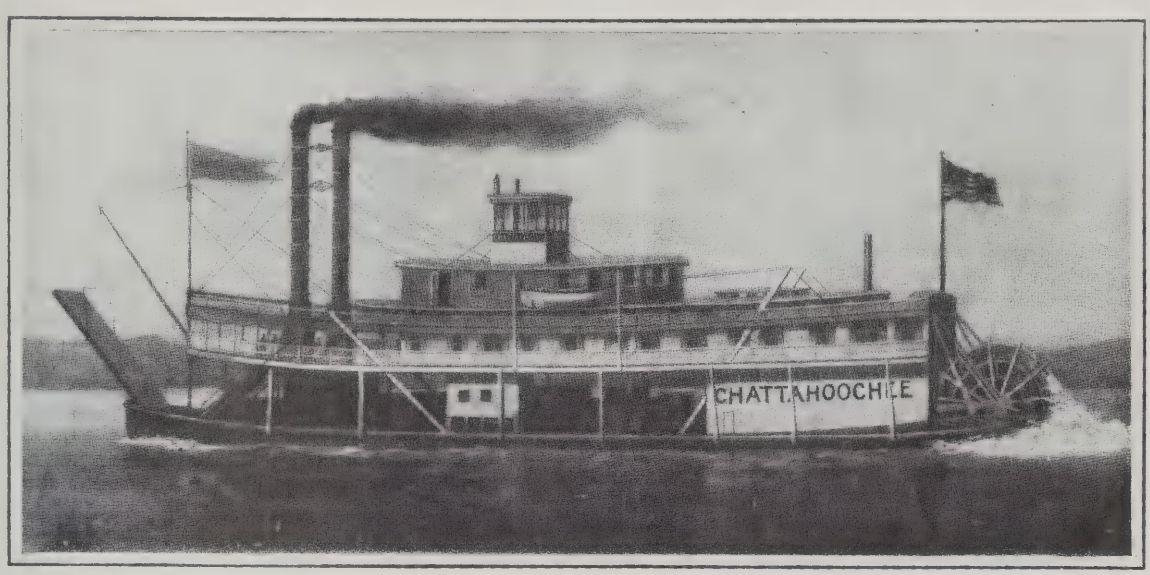
The opening of the experimental stage of steel in shipbuilding in this country may be said to date from the time of the permanent adoption of steel for shipbuilding in Great Britain. The vessels constructed were small in comparison to those built of steel in the United States a few years later, but it showed a confidence on the part of the builders in the use of steel in their construction, though there were many builders who withheld their approval of its use at the time. There were some severe criticisms in our technical papers, also, of the use of steel of such a high tensile strength for the purpose. Their construction received but a scanty indorsement in the trade at the time.

These vessels were all built by James Rees & Sons Company, of Pittsburg, Pa., and with two exceptions were for South American waters. The first built was the "Francisco Montoya," contracted for in May, 1878, for service on the Magdalena River in South America. It was a stern-wheel vessel, having dimensions of hull of 149 feet by 29 feet 9 inches by 4 feet, with two high-pressure engines, each having cylinders of 15 inches by 5 feet stroke. The angle iron used in the hull was made by Lewis, Oliver & Phillips, the channel iron by the Carnegie Steel Company, and the iron for bulkheads by Moorhead, McClean & Co. The hull plating was of crucible homogeneous steel of 70,000 pounds tensile strength, made by Howe, Brown & Co., Pittsburg, Pa. The bow plates and the knuckle plates were 3/16 inch thick, and the balance 6 pounds to the square foot, single riveted with ⅞-inch rivets. The hull was sent out in sections and re-erected at Barranquilla, and the vessel was completed ready for service under steam in February, 1879.

The "Victoria" was contracted for late in 1879 by the same company as the former vessel, and completed early in the next year. This vessel was 157 x 33 x 5 feet hold, being somewhat larger than the "Francisco Montoya," and with more power for propulsion. The angle iron was furnished by the Carnegie Steel Company. The hull plating was of the same kind of steel as used in the first vessel, and made by same steel company.

The Zulia River Navigation Company, of New York, contracted with the same builders in June, 1880, for a steel-hull stern-wheel steamboat named "Venezuela," to open navigation on the Zulia River in Venezuela. The hull was 120 x 24 x 3 feet deep. This was the first steam vessel built in the United States to have steel angles and floors, and of unequal legs, being 2, 2½, 3.7 pounds per foot. The rolls were made especially for this angle steel to secure the weight. This vessel may be said to be the first *all-steel* vessel built in this country. The angle steel was made by the Carnegie Steel Company. The steel of forward keel and bow plates was No. 8 gage, knuckle plates No. 7 gage, and balance of hull plating No. 10 gage; all of crucible homogeneous steel, made by Howe, Brown & Co. The six bulkheads were of No. 12 steel plate made by Moorhead, McClean & Co. There were steel transom and engine beams, with deck under engine beams of steel. During the same year the builders constructed for the Magdalena River, Republic of Colombia, the steamer "Roberta Calisto," and the "Irma" for service at Greytown, Nicaragua, both having steel plating like the former vessels. They were each 110 feet long. At the same time they built the "H. H. Benner" for the National Board of Health of the United States, having hull dimensions of 112 x 18 x 4 feet. The steel plate of the hull was made by the same manufacturers as that furnished for the previous named vessels. The bow and knuckle plates were 8½ pounds, bottom and sides 7½ pounds per foot; all double riveted. There were at the same time three steam launches built for the same board, each 37 feet long, and having steel plating of No. 16 gage.

The steamer "Chattahoochee" was contracted for in June, 1881, for service on the Chattahoochee River in Georgia, and was the first *all-steel* steam vessel built in the United States for service in American waters. The length on deck was 155 feet, beam 31½ feet, depth of hold at knuckle 4 feet 6 inches, shear forward 30 inches, with 30 inches guards. Frames 2 x 2½ inches by 4 pounds spaced 18 inches centers; deck beams 2 x 3 inches by 5-pound angles, of steel, made by the Carnegie Steel Company. The steel plating of the hull was made by Howe, Brown & Co., of homogeneous crucible steel of 70,000 pounds tensile strength. The forward plates and the knuckle plates were of No. 6 gage, and the balance of the plating No. 9 gage, all double riveted. The bulkheads were also of steel plate. The motive power was two high-pressure engines, each having cylinders of 15 inches diameter and 5 feet stroke, and three boilers, each 20 feet long and 42 inches diameter. It was a stern-wheel steamboat, having a waterwheel of 18 feet diameter. This vessel was run



THE FIRST ALL-STEEL RIVER STEAMER "CHATTAHOOCHEE."

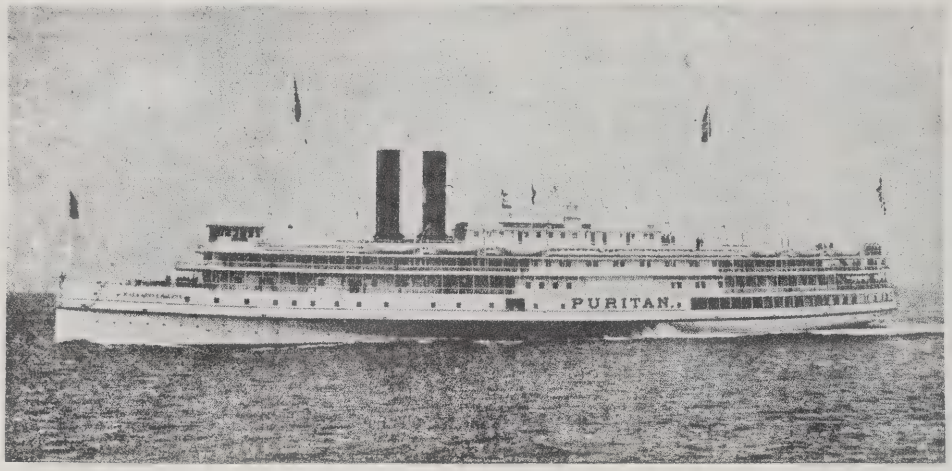
on the Chattahoochee River, then taken to the St. Johns River in Florida, and run there for several years, and subsequently was in service from Vicksburg on the Mississippi River to Greenville, Miss. She was destroyed by fire while lying up at Vicksburg for repairs on December 6, 1893. Estimated value of vessel at time of destruction, $40,000.

The Pusey & Jones Company, of Wilmington, Del., built for the Magdalena River in South America, late in 1879, two steam vessels about 130 feet long, having steel hull plating rolled by Hussey, Brown & Co., of Pittsburg, Pa. They also built a stern-wheel steamboat 120 feet long in 1881, and in 1883 another of the same type of 150 feet in length, both for South American waters, and having steel plating. In all, they constructed ten vessels in four years, both steam and sail, that were constructed partly of steel. If not in error, one or two of these vessels had imported steel plate used in their construction.

The manufacture of steel plate for shipbuilding purposes was still in its experimental stage for some years after the building of the "Sport" in 1873. It was at the time Congress was taking some action toward the improvement in our naval vessels, during their searching inquiries into the questions of the best means and material to be used in the construction of the proposed vessels, that the doubt of the advisability of using steel in the construction of the vessels came before them, both from those in private professional life, as well as those in the naval service. There was a marked difference of opinion on the subject among the members composing the first Advisory Board of the Navy, and that may have had some influence, through Congressional action, in having a second board appointed. There is no doubt but at this time most of the owners of steam vessels and builders of iron vessels in this country did not feel warranted in adopting the use of steel plate in the construction of vessels, mainly from the cause that this metal had not in the past given the best results in its use for other purposes. The manufacturers of steel in this country were at the time most persistent in their assurances that they could produce a uniform grade of steel suited to the wants of shipbuilding, and in quantities to meet all the demands of the constructors in this country at the time. There is no question but that they were one of the main factors in the rapid development of our steel shipbuilding. With them it was a question of an increase of business for their large plants. In 1882 there were eight steel mills in this country that were able to produce rolled steel plate, each of 20 tons and over per day, composed of the Otis Iron and Steel Company, of Cleveland, Ohio, the largest producer; Singer, Nimick & Co., Hussey, Howe & Co., Park Brothers & Co., Schoenberger & Co., Juniata Iron and Steel Works, Spang Steel and Iron Company, and Linden Steel Company, of Pittsburg, Pa., and the Bay State Steel Mills, of Boston, Mass. By 1884 there had developed among the constructors and builders more confidence in the use of steel, though at first there were several merchant vessels, built but partly of steel. More all-steel vessels began to take form after 1886. The adoption by the Navy Department of the use of steel in the construction of the first vessels for the new navy had its effect in the use of steel in the building of new vessels for the merchant service.

There was not at first any merchant vessel in this country built wholly of steel, as that metal at the time was to the designer and builder too much of an unknown quantity to be used wholly in the construction of a vessel. The steel manufacturers having every confidence in the mild steel plate they could make for structural work of shipbuilding and bridgebuilding, as equal to the better grade of iron plate for similar purposes, soon had its effect in inducing some of the builders to use the steel plating for some of the vessels. It was not eagerly sought by consumers from its first introduction for all-steel vessels, but had to work its way into favor on its merit, from the designers and owners of vessels, and this took three or four years.

About the earliest of these part-steel steam vessels was the "Alaskan," built by the Delaware River Iron Shipbuilding and Engine Works for the Oregon Railway and Navigation Company, launched August 7, 1883. It was the shell plating only that was of steel in this vessel, all other plates, shapes, etc., being of iron. The



THE SOUND STEAMER "PURITAN."

"Olympian," a mate to the "Alaskan," having steel plating also, was completed for the same company but a few weeks after the "Alaskan," by Harlan & Hollingsworth Company. The "Chicago," "Atlanta," "Boston," and the "Dolphin," then building at Chester, Pa., were all-steel even to the rivets. The "Atlanta" was launched October 9, 1884, the "Boston" on December 4, 1884, the "Chicago" December 5, 1884, and the "Dolphin" April 12, 1885.

At the time these Pacific coast vessels were completed the Harlan & Hollingsworth Company had two large steam yachts under construction; the "Electra" having angles, bulb T beams, and shell plating of steel, the balance of the hull structure being of iron. This vessel was launched in April, 1884. The "Nourmahal" was almost wholly of steel, but very little iron being used in building the hull. This vessel was launched in May, 1884. They also built the "City of Palatka" for Florida waters, partly of steel, that was finished late in 1884. There were a few ferryboats, tugs, and comparatively small steam yachts, their hulls being in whole or in part of steel, built during the same year at the yards on the Delaware River and on the Hudson River. The large steam yacht "Alva," built entirely of steel, by Harlan & Hollingsworth Company, was launched October 14, 1886.

The steel hull was now recognized as being the advanced type of vessel. At first, it was not adopted for another reason, on account of the increased cost of steel plate over iron plate, but in a very few years the price of ship steel was reduced to so near the price of iron plate that it was adopted more generally, and at once on the northern lakes, where a large demand was being made for increased tonnage.

Of the early *all-steel* vessels for the merchant service built on the Atlantic coast, may be named the "Puritan," of the Fall River line, launched July 25, 1888; "Iroquois," of the Clyde line, in 1888; "Leona," of the Mallory line; "Yumuri" and "Orizaba," of Ward line, in 1889; the "Yucatan," for the Ward line, and the "Seguranca," for the New York and Brazil line, in 1890; "El Rio," for Southern Pacific Company, in 1892.

There were 43 steam vessels built on the Atlantic coast, in whole or in part of steel in the construction of the hull, from 1884 to 1890, consisting of coastwise steamships, steam yachts, and ferryboats, of an aggregate of 31,183 net tons. The largest of these vessels was the "Seguranca." There were equally as many built in same time of iron entirely.

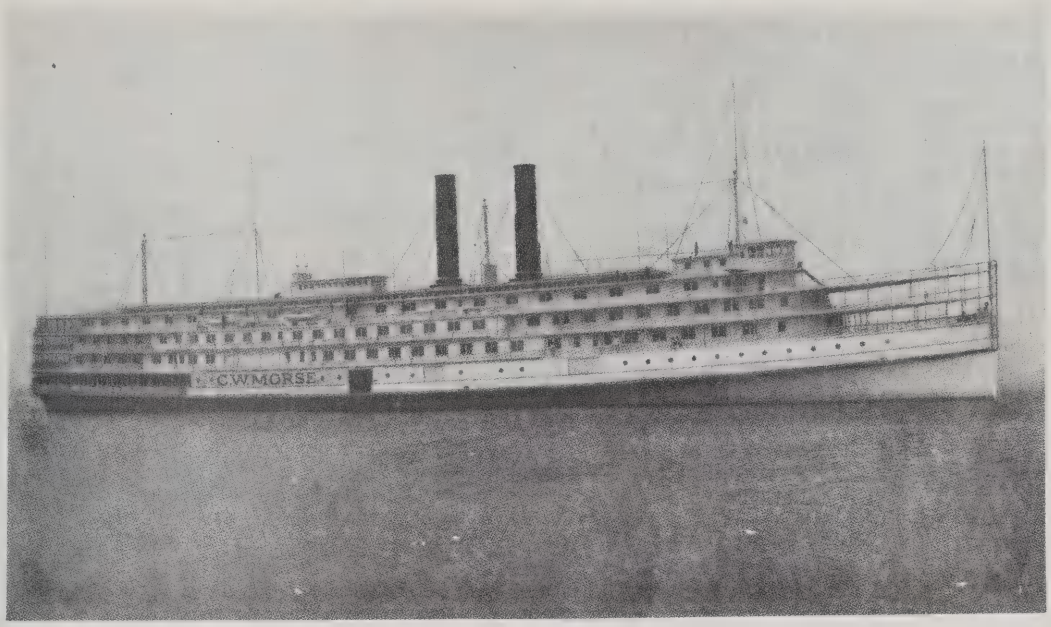
The first steel vessels of later years built in Great Britain were constructed in 1878 of mild steel:

	Iron. Tons.	Steel. Tons.
1878	.....	4,470
1880	459,994	35,373
1885	303,825	162,641
1890	42,069	957,894
1895	7,789	862,595
1897	9,206	763,766
1901	.....	1,438,700

The Lighthouse Board had built in 1887 at Baltimore, Md., by H. A. Ramsay & Co., the twin-screw tender "Zizania," having a steel hull complete. This vessel was the second steam vessel having *two sternposts* and two rudder-posts. The first one was built by J. H. Dialogue at Camden, N. J., for service at Galveston, Texas, a few years before. The motive power of the "Zizania" was a fore-and-aft compound engine operating each screw. On account of the contractors becoming financially involved before the vessel was launched, the board was compelled to finish the vessel themselves. They also had built the same year two steel-hull light vessels at Marcus Hook, Pa., by Woodbridge & Hutton. These vessels were built on the "combination" system, having a complete steel hull, the outside of the hull plating having a layer of tarred hair felt, this being covered with yellow pine planking fastened with iron bolts, and the hull then sheathed over the planking with hard-rolled zinc sheathing.

NORTHWESTERN LAKES.

The development of iron shipbuilding on the northwestern lakes was of very gradual growth, for it is found that in twenty years after the building of the "Merchant" in 1862, there were but 49 steam vessels built of iron for the lake service. The demand for larger vessels was met by the limited depth of water in parts of the Detroit River and St. Clair River. The "Cuba" and the "Java," built in 1872, were about the largest vessels on the lakes for over five years. The competition with the railroads, and the supply of oak timber for building wooden vessels running short at this period, were other causes that brought about in a few years the more general adoption of the iron-hull vessel. This change in favor of iron-hull vessels had no more than been fully recognized by the builders



THE HUDSON RIVER STEAMER "C. W. MORSE."

and vessel owners on the lakes, than the Navy Department decided to adopt the use of steel in the construction of the new vessels for the navy. This brought before the marine interests of the lakes another radical change in the material for construction, just at a time when they had proposed a marked advance in the building of their vessels. Having the raw material for the making of steel, in the shape of the ore and the coal at their own doors, and the steel rolling mills so close at hand, they very soon adapted themselves to the change, and it was but a few years before they were building more steel-hull vessels on the lakes than were under construction on the Atlantic coast. They were now making up lost time.

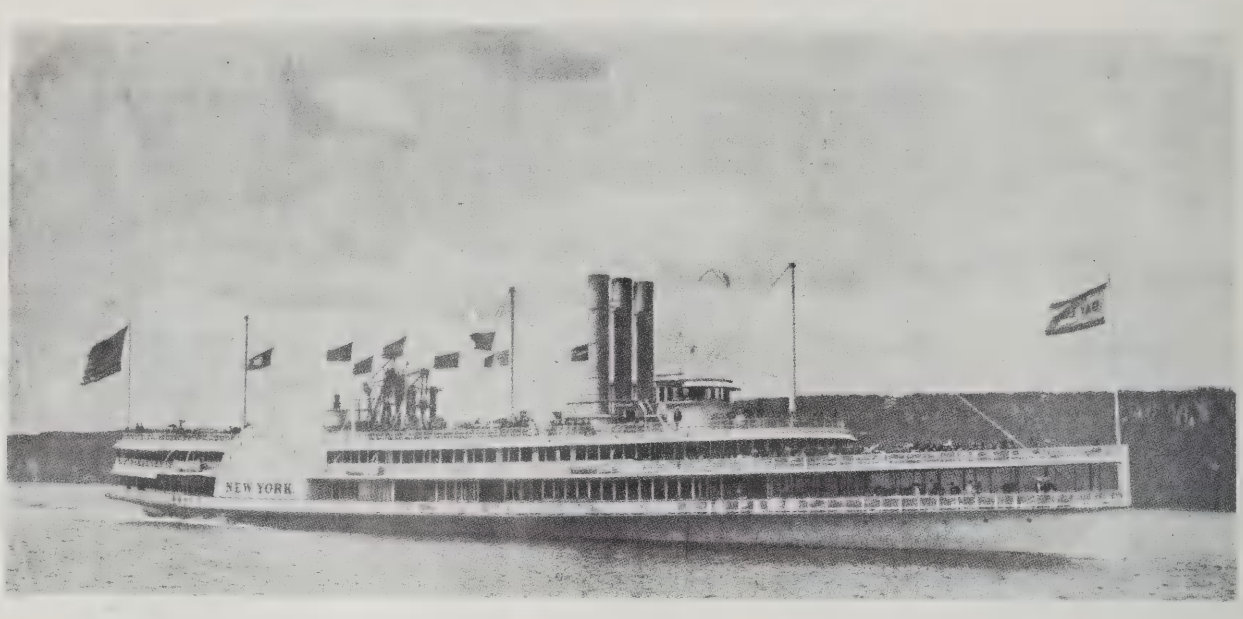
There were causes for this apparent backwardness on the part of the vessel owners on the Atlantic coast, in adopting the use of steel to a larger extent at first. We must remember that the lines of the coastwise steamers, as well as those on the rivers along the coast, had been for about ten years before the opening of the steel era laying aside the wooden-hull vessels, and building new vessels having iron hulls, so that when the subject of steel for construction began to be agitated, there was a large percentage of the new vessels on the coast of iron. On the lakes it was different. They had but very few iron-hull vessels; probably not more than fifteen in the passenger and freight business in 1882.

The large demand that was now made for material of steel in construction of steam vessels, bridge building, and steel framing for large buildings, was such that the owners of the steel mills had prior to this time become interested in the opening of new mines of ore in the Lake Superior mining region, and steamship companies were formed by those in interest, who had new vessels built on the lakes for the transportation of their own raw material. This brought about a boom in shipbuilding in 1886 of steel vessels that has continued to almost the present day, with but little change, except enlarged size of vessel. At the same time the Navy Department entered upon a plan for the further enlargement of the fleet of naval vessels, that called for the production of hundreds of tons a year of steel for their construction, and this increased the demand for lake tonnage to supply the raw material for the making of the finished steel. What increased the demand a few years later still further, was the successful operation of the armor-plate mills, in producing the armor for the United States naval vessels. So in the course of a few years the use of iron was turned aside, and steel adopted in its place, in the building of vessels on the lakes. It is thus seen there was more than one cause for its rapid growth on the lakes. They have also made marked advances in the methods of construction, and it was but a few years before the builders on the lakes were in the front rank in their methods of construction. As the shipbuilding plants were mostly all new in 1886, they had the advantage of the equipment of their plants with all the improved and up-to-date power and labor-saving machines, that gave them much advantage for the time over the older and longer established builders on the coast.

The use of mild steel for the hulls of the modern type of steam vessels on the northern lakes was first made use of in two vessels built at the Wyandotte Shipbuilding Company's yard. These were the "Albany" and the "Syracuse," propellers of 1,900 tons each, built for the Western Transit Company, of Buffalo, N. Y., and were *entirely of steel.* The "Albany" was completed in September, and the "Syracuse" in October, 1884. The former was sunk in collision with the "Philadelphia" on November 7, 1893. These vessels had fore-and-aft compound engines built by the Detroit Dry Dock and Engine Works. The same builders launched in April, 1885, the twin-screw propeller "Mascotte," of 112 x 22 x 8 feet, having part steel hull and two high-pressure engines.

The propeller "William Chisholm," of 1,500 tons, was launched by the Globe Iron Works Company August 7, 1884, having iron and steel plating and steel angles in the hull, and fitted with a compound engine.

The "Tioga," of 2,080 tons, was completed in July, 1885, at Buffalo, N. Y., by the Union Dry Dock Company, having the larger part of the hull constructed



THE HUDSON RIVER STEAMBOAT "NEW YORK."

of steel, and having steeple compound engines, for the Union Steamboat Company.

The first *all-steel* hull built by the Globe Iron Works Company was the "Spokane," of 2,350 tons, for the Wilson Transit Company, having fore-and-aft compound engines, and launched in July, 1886.

The first *all-steel* hull by the Union Dry Dock Company was the "Susquehanna," of 2,780 tons, having three-cylinder compound engine, for the Erie and Western Transportation Company, launched September 4, and completed in November, 1886. This vessel was designed as a larger carrier, and to be more economical in operation than the "Onoko," that was hardly fulfilled in all particulars when in service.

The next year the Globe Iron Works built the *all-steel* propeller "Ira H. Owens," of 1,750 tons, for the Owens line, having compound engines.

To this time all the steel-hull vessels on the lakes had been equipped with compound engines, but the triple-expansion engine had been built for merchant vessels on the Atlantic coast for a few years past, and their economy in operation over the compound engine had been generally recognized. The operation of many of their steam vessels on the northern lakes with high-pressure steam, or as non-condensing engines, had been the practice for many years, as the change to the compound engine, and then the triple-expansion engine, did not involve such a radical change in the working steam pressure that it had in the steam vessels on the Atlantic coast, where the low-pressure condensing engine was the general type of marine engine, even in most of the propeller engines. The first engine of the triple-expansion type on the lakes was in a steam yacht named "Peerless," built by the William Cramp Shipbuilding Company, and sold to parties on the lakes in 1885 or 1886. The first of that type of engine built on the lakes was placed in the wooden-hull steamer "Roumania," built in 1887 at West Bay City, Mich., and the engine by S. F. Hodge & Co., of Detroit, Mich., and the same year one was placed in the iron-hull steamer "Cambria," built by the Globe Iron Works Company. It was not until the next year that the modern type of steam vessel, having the steel hull and the triple-expansion engine, was adopted, when the "Carona" and the "E. P. Wilbur" were built by the Globe Iron Works Company, and the six vessels for the Northern Steamship Company, by the same company, and the "Scranton" by the Cleveland Shipbuilding Company. This was the opening stage of the boom in shipbuilding on the lakes.

There were built in 1891, 29 iron and steel steam vessels having an average of 1,671 net tons.

In 1893, 25 vessels, average 1,990 net tons.

In 1896, 25 vessels, average 2,544 net tons.

In 1900, 26 vessels, average 3,700 net tons.

In 1902, 33 steel vessels, average 3,265 net tons.

In 1904 there was a total gross tonnage built on the lakes of steam vessels of 152,773 tons.

In 1898 there were 216 iron and steel steam vessels, having a total gross tonnage of 407,908 tons.

In 1904 there were on the northern lakes 421 iron and steel steam vessels of a gross tonnage of 1,088,960 tons, and 30 iron and steel sailing vessels of a gross tonnage of 100,633 tons.

The periods of the changes to the advanced types of steam vessels may be stated:

The " Philadelphia," built by David Bell in 1868, of 1,463 tons; the "Onoko," by Globe Iron Works Company in 1882, of 2,164 tons; the "Globe," by the Globe Iron Works Company in 1894, of 2,995 tons; the "Victory," by the Chicago Shipbuilding Company in 1895, of 3,774 tons; the "North West," as a passenger steamer, by Globe Iron Works Company in 1894, of 4,244 tons; the "S. F. B. Morse," by F. W. Wheeler & Co. at West Bay City, Mich., in 1898, of 4,936 tons; the "Douglass Houghton," by Globe Iron Works in 1899, of 5,332 tons; and "James C. Wallace" in 1905, by American Shipbuilding Company, of 6,684 tons.

There was a breaking away from the old form of vessel when the Union Steamboat Company had constructed in 1887 at Buffalo, N. Y., two steel-hull vessels of 1900 tons each, named "Owego" and "Chemung." They were modeled after our coastwise steamers, having finer lines than the more modern lake vessels, intended for higher speed, and were fitted with triple-expansion engines built in New York. While

they made better time than the usual type of lake vessel, they were more expensive to operate, and smaller carriers of freight for their dimensions. The "Owego" is credited with having made the trip from Buffalo to Chicago in May, 1889, in 58 hours, and in the next month the "Chemung" over the same route made the trip in 54 hours. The "Owego" made the round trip in June, 1890, from Buffalo to Chicago and return in 5 days 5 hours and 3 minutes, going light, and returning with 85,000 bushels corn. At this time the "Harlem" and the "Hudson" were considered the most modern and profitable vessels to their owners, of those on the lakes.

The lake shipowner and the shipbuilder both have peculiar conditions to meet in connection with the draft of water and load to be carried. Originally the St. Clair River had seven principal mouths, and these were obstructed by sandy deposits, reducing the depth of water from 2 to 6 feet, and the Lime Kiln crossing in the Detroit River could not be depended upon for more than 13 feet of water. So here were the restrictions that bound the designer for years until 1870, when there was a depth in the canal of 13 feet at St. Clair Flats, that was further increased in 1873 to 16 feet, and in 1893 to 18 feet depth over the bars and through the canal, and at the present time 21 feet has been obtained; and over the Lime Kiln crossing the same depth of water has been found. Taking the depth of water, kind of freight that is mainly transported, and they have designed a vessel of a peculiar but thoroughly efficient type. The vessels have a moderate draft of water, fair speed, and economy of operation, with unrivaled facilities for loading and unloading their cargoes at their docks.

The most novel production of late years in steel shipbuilding in this country has been the whalebacks of the northern lakes, constructed by the American Steel Barge Company at West Superior, Wis. They were the invention of Alex. McDougall. Their first steam vessel was the "Colgate Hoyt," of 276 x 36 x 22 feet, that was completed in the fall of 1890. The "Joseph L. Colby," of about the same size, and having a fore-and-aft compound engine of 28 and 50 inches by 42 inches stroke, and operated by 120 pounds steam, was completed in November, 1890, and sent to the Atlantic coast. In the following month the "C. W. Wetmore" was sent from the lakes with 95,000 bushels of grain through the canal, and arrived at Quebec July 5, 1891, and shortly after left for Liverpool. She was reported at New York on August 14, and shortly after cleared for the Pacific coast, and passed San Francisco in 76 days from Philadelphia, Pa. She was lost on the Pacific coast. The "E. B. Bartlett," a duplicate of the "C. W. Wetmore," but having a triple-expansion engine, was finished in 1891. The "Colby," "Bartlett," "Wetmore," and "A. D. Thomson" were the only steamers sent to the Atlantic coast. There was one passenger whaleback steamer built in 1893, named "Christopher Columbus," having accommodations for 5,000 passengers that ran from Chicago to one of the lake ports. There have been sixteen steamers and twenty-four barges built of this type on the northern lakes in fourteen years.

WESTERN RIVERS.

The building of steel-hull vessels in the Western States, besides those previously named, took place very soon after steel was used for a similar purpose on the northern lakes, by the Iowa Iron Works at Dubuque, Iowa. Their first steel vessel was the sternwheeler "Cherokee," of 220 feet in length, in 1888, followed in two years by the "Ferd. Herold," of 244 feet in length, both having high-pressure engines. The next year they built the snagboat "James B. McPherson" for the U. S. Engineer Corps, of 178 feet in length, and fitted with compound condensing engines. In 1892, 1893, and 1894 they built a number of small river boats, torpedo boat "Ericsson," and revenue cutter "William Windom." In 1899 there were four sternwheel steam tenders for the Mississippi River Commission, of 171 feet in length; and in 1902 the sternwheeler "Sprague," of 276 x 61 x 7 feet 4 inches. This company has built about sixty iron and steel vessels to the present day. There have been some steel hulls constructed lately at Jeffersonville, Ind.

On the Pacific coast the first steel hull was built at the Union Iron Works in 1885 as a propeller, and named "Arago," of 620 tons. Two small vessels were built the next year, and in 1887 the "Premier," of 602 tons, for the Canadian Pacific Railroad Company, was launched by the same company. In the next ten years the same builders had completed, and under construction for the U. S. Navy Department the battleships "Oregon," "Ohio," and "Wisconsin," the monitor "Monterey," the protected cruisers "Olympia" and "San Francisco," gunboats "Marietta" and "Wheeling," and torpedo boat "Farragut."

There was a plant erected in 1895 at Portland, Oregon, by Wolff & Zwicker, who received contracts for building three torpedo boats in the next two years, from the Navy Department.

Iron shipbuilding did not show a steady, increasing growth in the number of vessels built for the first twenty years, that would be expected in a country having the raw material within its boundaries in such quantity as the United States possesses, and the talent and means to convert it into the finished product. During the decade from 1860 to 1870 there were a larger number of iron vessels constructed than there had been built prior to the former date. It was not until 1870 that it can be said that iron shipbuilding in this country began to develop to such proportions as to attract attention, though there were two plants of large size on the Delaware River that were devoted to that industry alone. At this time the fleet of our iron-hull merchant steamers, built in this country, was not imposing in numbers. There were seventeen coastwise steamships that included the "Juniata," "Crescent City," "Mississippi," "Merrimac," "Ellen S. Terry," "Volunteer," "Regulator," "Champion," "S. R. Spaulding," "Benj. Deford," "Continental," "Havana," "Matanzas," "Gulf Stream," "Benefactor," "Wyanoke," "William Lawrence." There were only two on Lake Erie, the "Merchant" and the "Philadelphia." In the Gulf of Mexico service there were six at New Orleans and two at Mobile, Ala. On the western rivers there was but one, just completed. On the rivers along the Atlantic coast there were about twenty passenger and freight vessels, the larger number of them being in service on the Delaware River. There were also ten or twelve iron steam canalboats, and six new steam colliers, of about 600 tons each, owned by the Philadelphia & Reading Railroad Company. There were a few iron-hull "double-enders," that had been sold by the Navy Department, which were altered, and placed in coastwise freight lines. This shows a total of at

PACIFIC OCEAN STEEL-HULL STEAMSHIP "COREA."

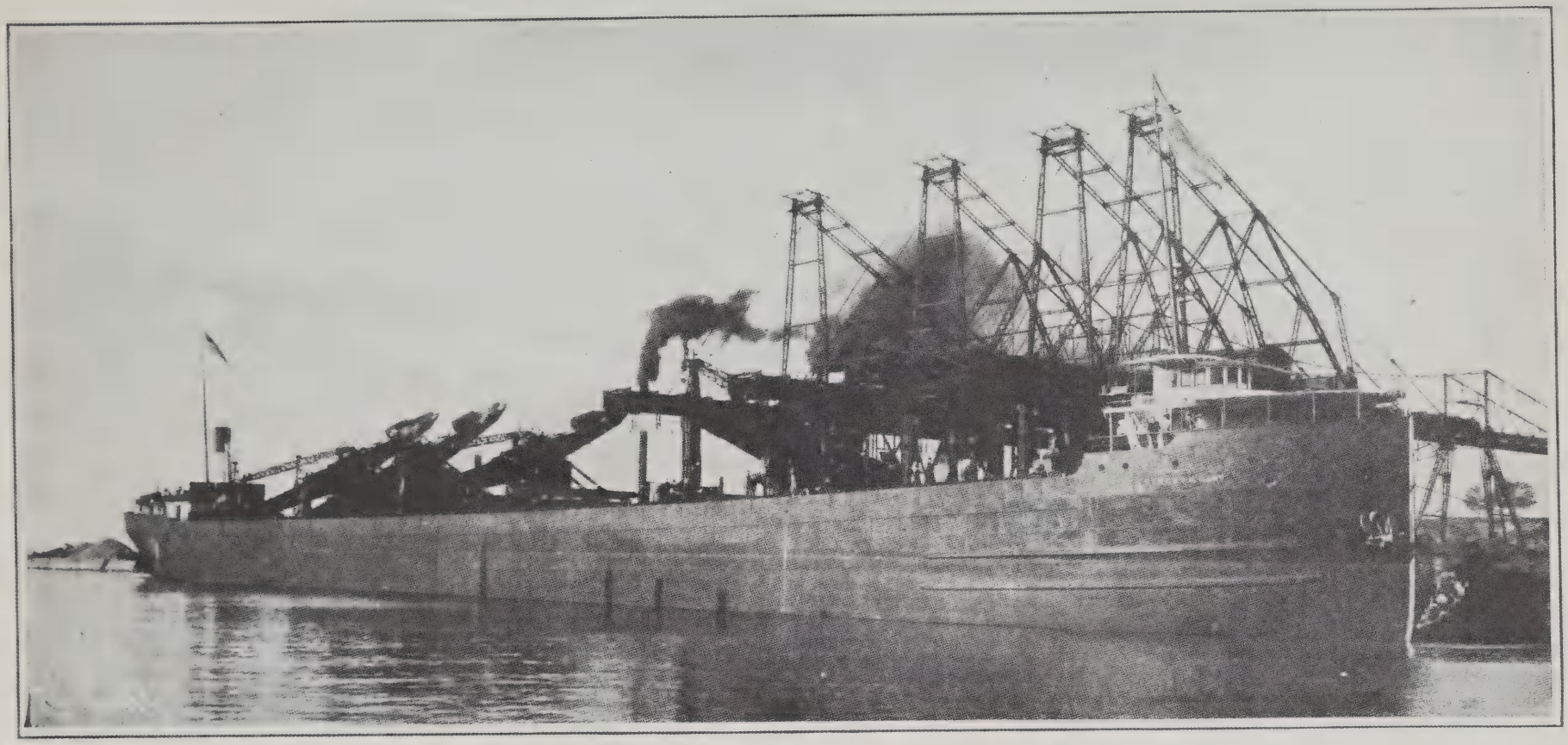
least 64 iron-hull steam vessels in service in 1870, that were built in the United States. At this time there were several iron-hull vessels having an American register, or under American enrollment, that were built in Great Britain, that have not been included in the above figures. The four iron steamships built by the Cramp Shipbuilding Company for the American line from Philadelphia to Liverpool, were built a few years later. When it is taken into consideration that in the next decade there were built in the United States 233 iron-hull vessels, it shows how the business of iron shipbuilding had grown in ten years, and nearly one-half of that period the business of the country had been paralyzed from the effects of a financial panic. A large percentage of this increased tonnage was for the coastwise trade. In the next decade, from 1881 to 1890, it is found that there were built 363 steam vessels, some of iron and some of steel; and from 1891 to 1900 there were 530 steam vessels, nearly every vessel being constructed of steel. These figures tell very plainly what the development of our shipbuilding plants has been in ten years even. When we look back to what they were thirty years ago, large enough probably for the surrounding conditions, with the comparatively small plants, and having but few labor-saving tools or machines for the preparation of the material of construction for an iron vessel, it seems almost impossible that such a transformation has taken place in such a short period of time, but the "hustling" methods and ingenuity of the American engineer and mechanic have produced these marvelous results. There will be further advances made in the future, no doubt, in the manner of construction, probably not so radical, or to such a great extent as there have been in the past thirty years or more, but competition of the builders will compel new methods to be adopted so as to reduce the cost of building, if for no other purpose.

HAND AND POWER RIVETING MACHINES.

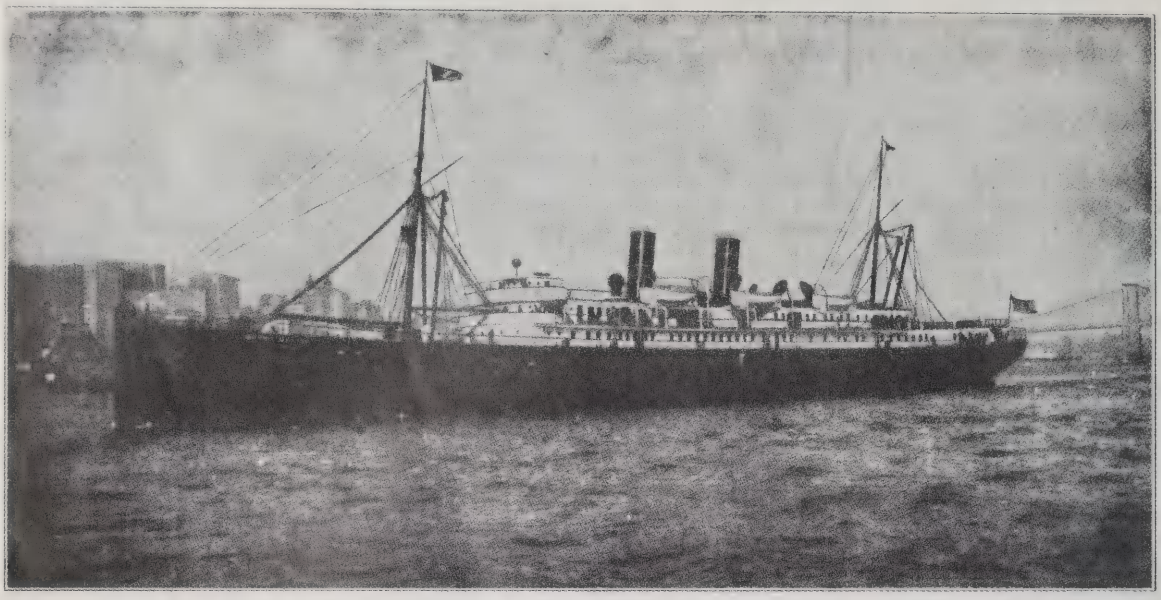
The first hand riveting machine of which there appears to be any record is one described by William Fairburn in 1839, in a paper read before one of the British engineering societies, in which he says in part: "A riveting machine for riveting steam boilers, or vessels of wrought iron or copper, that completes eight rivets of ¾-inch diameter in a minute, with the attendance of two men and two boys to the plates and rivets."

In this country hand work appears to have been the only means employed in riveting steam boilers to about 1854, when we find in an engineering journal a description of a riveting machine used at that date: "Riveting machinery is unusual in this country. One or two machines in New York and two in Philadelphia are all that are in use in the United States. So far it has been successfully applied only to the riveting of plain cylinders, like boiler shells, flues, domes, etc. The rivet is formed and closed by compression between two dies; the one stationary in the side of a stout iron post, the other movable upon the end of a horizontal bar, operated by a cam and toggle joint. The cost of this machine is not far from $1,500 including the patent right. We saw the machine closing 12 rivets a minute, leaving nothing to be done saving trimming and calking the edges of the sheets. Three men attended the machine, while one hand heated the rivets, and another passed them to the machine. Two smart riveters will close up from 400 to 450 rivets in a day of ten hours, one hand heating, and one passing rivets as with the machine." The Port Richmond Iron Works and the Southwark Foundry at Philadelphia, Pa., and the Novelty Iron Works at New York city, had these machines in operation in their works at the time. It is not at all improbable that some of our locomotive works at the time had these riveting machines as one of their tools. There appears to be evidence that the Novelty Iron Works, of New York, had a hand machine for riveting iron boilers as early as 1843 or 1845, but whether it was an experimental machine or not does not appear.

The power riveting machine first came into use in Great Britain before 1860. It was operated by a crank cam movement, but the work performed was very irregular. The steam riveter came to be used through necessity, at the time of a strike of the labor in one of the large plants, and was succeeded by the Tweed-



MODERN STEEL-HULL ORE CARRIER "ELBERT H. GARY"—MACHINERY LOCATED IN THE STERN.



STEEL STEAMSHIP "MORRO CASTLE," SAILING BETWEEN NEW YORK AND CUBA.

dell patent hydraulic machine in 1871. This riveter was introduced in this country about 1876, and the patent was controlled by William Sellers & Co., of Philadelphia, Pa., for a few years. They built the first portable hydraulic riveter on the Tweddell system for the Edge Moor Works in 1873, and a stationary hydraulic riveter for the same works in 1877. This patent was subsequently managed in this country by the Morgan Engineering Company, of Alliance, Ohio. All of the stationary hydraulic machines, of whatever make, were termed "bull machines."

The steam riveter was the earlier of the power riveters built in this country. William Sellers & Co. built in 1868 their first stationary steam riveting machine for the Pennsylvania Railroad Company, and this was rapidly followed by similar machines for the Danforth Locomotive and Machine Company, Lehigh Valley Railroad Company at Hazelton, Pa., Baldwin Locomotive Works at Philadelphia, Pa., Dickson Manufacturing Company at Scranton, Pa., Schenectady Locomotive Works at Schenectady, N. Y., Manchester Locomotive Works at Manchester, N. H., and one for William Cramp Shipbuilding Company at Philadelphia, Pa., in 1872. Belt-driven shears and punches were in use long before these dates. A little later, direct power shearing machines, to trim the edges of the long and heavy iron plates, were brought into use.

The weak point in the direct-acting steam riveter was that inasmuch as the work performed was done by a blow, the shock was in time destructive to the machine itself, and very often injurious to the work operated upon. The subject of riveting by power had for some time attracted the attention of mechanical engineers, as about 1870 so much heavier material was being used in construction of iron vessels, bridges, etc., that it was no longer possible to work to advantage with the old-fashioned hand machines. The objections to the steam riveter were subsequently met by the hydraulic power machine.

The pneumatic portable riveter was first brought into notice through J. F. Allen's portable pneumatic riveter, that was patented in March, 1877, but was a few years later much improved. It was first brought into use in 1879 at the J. B. & J. M. Cornell works at New York city, Cambria Iron Works, Johnstown, Pa., Lane & Watson Boiler Works, Bridgeport, Ct., and in 1881 John Roach & Son, Chester, Pa.

The direct use of electricity to operate the large tools in the machine and boiler shops of the large plants has been of very recent date. It was in use ten years or more ago to operate the compression machine of the pneumatic riveter, that made it but an auxiliary power to the riveter. The pneumatic and electric riveter has come largely into use since about 1895, when large bridge work, the steel framing in the "skyscrapers" of our large cities, and the elevated railroad structures of our cities began to assume such large proportions. The keen competition in iron structural work has been the cause of the invention and improvement of power machines and tools of the later years. There is probably no one section of this country where this strife for the best labor-saving machines, for the construction of iron and steel vessels has been carried further than in the comparatively new plants on the northern lakes.

IRON AND STEEL SHIPBUILDING PLANTS.

	1890	1894	1900	1904	1908	1904
Atlantic coast	13	12	14	18	23	23
Northern lakes	3	4	8	8	10	10
Western rivers	2	3	3	2	3	4
Pacific coast	0	1	1	2	4	4

IRON AND STEEL SAILING VESSELS.

At the time of the expansion of iron shipbuilding in 1870, the cost of material and labor was such as to make it almost prohibitive in constructing iron-hull sailing vessels. Wood was so much cheaper as a material for construction, and freight rates were too low in price to permit of the building of an iron-hull vessel, to make it a profitable investment to the owner.

AVERAGE PRICES OF IRON AND STEEL SHIPBUILDING MATERIAL DELIVERED AT SEABOARD, OR ON THE NORTHERN LAKES, FROM 1882.

	1882	1883	1885	1886	1888	1890	1895	1897	1899	1900	1902	1904	1905*
Iron shell	4	3	2.75	2.4	2.4	2.5	1.25			1.4			
Iron flange	5	4	3.25	3.4									
Iron firebox	6	5	4.75	4.25									
Iron angles	2.0	2.4	2.4	2									
Iron beams	4	3.5	3	3									
Iron channels	4.2	3.5	3	3									
Iron shell plate	3.6	2.5											
Steel ship plate	5½	4½ to 5	5.25	3	2.3	2.4	1.30	1.20	2.70	2.00	2.30	1.75	1.73
Steel plate boiler and flange	7	5¾ to 5¾	4.75	3.5	3.75	2.8	1.60	1.30	2.90	2.30	3.00	1.85	1.88
Steel angles				2.35	2.10	2.4	1.35	1.25	2.15	2.40	2.60	1.55	1.74
Steel beams				4	3.3	3.10	1.40	1.50	2.15	2.60	2.70	1.85	1.98

* For nine months.

But we made history very fast in this line in a few years. Labor-saving machinery soon began to take form in our machine shops and shipyards, and by 1880 much of the work that had formerly been done by hand was now executed by power, and with the lower prices for ship iron or steel, it soon had its effect to lower the price per registered ton of the completed vessel. These conditions were taken advantage of by our vessel owners, and since then several iron-hull sailing vessels have been constructed. At the present time these vessels are of the type of the large six and seven masted fore-and-aft schooners.

The first iron-hull sailing vessel built in the United States was the schooner "Mahlon Betts," constructed by the Pusey & Jones Company in 1855, and enrolled May 16, 1855. The dimensions were 101 x 27 x 9 feet, 216 tons. Her original owners were Mahlon Betts, Pedrick, Price & Co., the builders of the vessel, and others. This vessel was under charter for several months during the rebellion to the Army Department. She was totally destroyed by fire while lying in Little Egg Harbor, N. J., on May 30, 1863, while on a voyage from New York to Washington. The next was the iron brig "Novelty," built in 1868 by the Atlantic Works at East Boston, Mass., for Spaulding, Nash & Co., of Boston, to transport molasses in bulk from the West Indies. The vessel was 130 x 27 x 11 feet, and the cargo space was divided so as to form seven tanks to hold the molasses. These tanks held about 90,000 gallons. The vessel ran to Matanzas, Cuba, mainly, and was in active service until April 1, 1874, when she sprang a leak during a gale on the coast and was lost. Reaney, Son & Archbold, at Chester, Pa., constructed a sloop yacht in 1871 named "Vindex," of 37 tons, having dimensions of 63 x 17 x 8 feet. The largest sailing vessel that had thus far been built was the "Iron Age," a bark built by Harlan & Hollingsworth Company for Tupper & Beattie, of New York, and launched October 30, 1869. Her registered tonnage was 650 tons. The cost of this vessel was $85 a registered ton for the hull, and $15 a ton for the rigging and outfit. The same builders in 1879 constructed a yacht named "Mischief," of 41 tons, having an iron hull. The William Cramp Ship and Engine Building Company built the first three-masted iron-hull schooner in 1880, named the "Josephine." This vessel was 126 x 34 x 10 feet deep in the clear, and is still in service with Mobile, Ala., as the home port. The first cost was $95 a ton complete. The American Shipbuilding Company, of Philadelphia, Pa., built the next three-masted schooner with an iron hull in 1884, named "Red Wing," of 415 tons with dimensions of 136 x 33 x 12 feet. Up to this time the vessels built were comparatively small sailing vessels, but in April, 1883, the Delaware River Iron Shipbuilding and Engine Works launched the iron-hull ship "Tillie E. Starbuck," of 1,829 tons, for W. H. Starbuck, for service on the Pacific Ocean. In the following September the American Shipbuilding Company, of Philadelphia, Pa., H. H. Gorringe, president, launched the ship "T. F. Oakes," of 1,897 tons, for the same party and the same service. The next year the same builders launched another ship named "Clarence S. Bement," of 1,727 tons. There now came a long interval of time before the metal-hull sailing vessel was again under construction; and during that period the wooden-hull, schooner-rigged sailing vessel had advanced from the four to the five masted vessel and from 900 to 1,600 tons, and steel was now used in place of iron.

Those constructed later include: Ship "Dirigo," built 1894, 2,845 tons, Bath, Me.; ship "E. M. Phelps," built 1898, 2,715 tons, Bath, Me.; bark "Kaiulania," built 1899, 1,430 tons, Bath, Me.; ship "Edward Sewall," built 1899, 2,916 tons, Bath, Me.; ship "Arthur Sewall," built 1899, 2,919 tons, Bath, Me.; ship "Acme," built 1901, 2,987 tons, Bath, Me.; ship "W. P. Frye," built 1901, 2,998 tons, Bath, Me.; ship "Astral," built 1901, 2,987 tons, Bath, Me.; ship "Atlas," built 1902, 3,006 tons, Bath, Me.; schooner "Thomas W. Lawson," built 1902, 4,914 tons, Quincy, Mass.; schooner "Kineo," built 1903, 1,867 tons, Bath, Me.; schooner "W. L. Douglass," built 1903, 3,470 tons, Quincy, Mass.

There have been built on the northern lakes since 1894 several schooner tow barges having a steel hull, and a few of them having the tonnage measurement of 4,000 tons. These vessels are fitted with short masts, mostly three in number, and are furnished with sails for use in case of emergency only. They have no use on these lakes for the large schooners such as the "Thomas W. Lawson," as the cargo steamers on those inland waters carry their freight at such a low rate that sailing vessels cannot successfully compete with them.

GENERAL INDEX

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SHIPS' NAMES INDEX

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